# Digging for Growth? Which infrastructure development should African countries prioritise?

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**Acknowledgement**

This thesis was motivated by the passion to develop the African continent and the hope to see her flourish.

Special thanks to my husband, Ontiretse Modise, who played Mom and Dad to our three kids, Motheo, Tshiamo and Mmamosa, during my absence. To my mom and brother, Masilo, I don't know how I would have made it without your support.

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Africa, rise!

**Abstract**

This study investigates the impact of infrastructure development on economic growth among 10 selected African countries over a period of 15 years from 2000 – 2015. The study uses panel data to analyse the effect of infrastructure components on economic growth. The findings show that infrastructure development impacts economic growth, and further identifies that African countries should prioritise investing in Power and the Human Development Index (HDI). These results suggest a need for reform in policies and planning. African states will be required to invest time in planning their infrastructure investment in advance with clear timelines and funding requirements. To attract Foreign Direct Investment (FDI) in power infrastructure, States will need to reform both monetary and political policies to create an attractive investor environment. Lastly, States will need to reform fiscal policies to prioritise investment in the HDI.

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## Glossary of Terms

AU – African Union

AfCFTA – African Continental Free Trade Area

ASEAN - Association of Southeast Asian Nations

ICT – Information and Communications Technology (and Information and Communications Technology per capita)

E – Employment infrastructure per capita

FDI – Foreign Direct Investment

GDP – Gross Domestic Product

GDPPC – Gross Domestic Product Per Capita

GNP – Gross National Product

HDI – Human Development Index

ICT – Information and Communication Technology

LE – Life Expectancy

MENA – Middle East & North Africa

MNO – Mobile Network Operator

OECD – Organisation for Economic Co-operation Development

P – Power infrastructure per capita

SA – South Africa

SADC – Southern African Development Community

SDG – Sustainable Development Goals

SSA – Sub-Saharan Africa

T – Transport infrastructure per capita

W&S – Water & Sanitation

WS – Water & Sanitation infrastructure per capita

# Chapter 1

# Introduction

## 1.1 Background

During its ordinary meeting in Addis Ababa, Ethiopia, in January 2012, the African Union (AU), consisting of 55-member countries, placed an African Free Trade ideology on its Agenda. The matter was subsequently discussed and finally bedded down in May 2018 when 44-member countries signed the agreement, which was later ratified by 18 more-member countries. The agreement established the African Continental Free Trade Area (AfCFTA) to enable regional trade at reduced or no import tariffs.

The AU recognised that signing the AfCFTA agreement is not going to independently resolve all of Africa's challenges – the implementation of the AfCFTA will have to be accompanied by regional development. The member countries identified four pillars that will assist in developmental regionalism: 1) fair trade integration; 2) collaboration on transformative industrialisation and establishing regional value chains; 3) co-operation on cross-border infrastructure funding; and 4) accordance of democracy, governance, peace and security (Ismail, 2018).

Of the four pillars, the member countries identified infrastructure development as a major stumbling block due to the financial investment requirement (Ismail, 2018). There are two types of infrastructure assets -productive and soft . Productive infrastructure – as widely defined – consists of four components, namely: Energy, Telecommunication, Logistics (road, rail and port) and Water & Sanitation. All four components play a critical role in facilitating and enabling achievement of the soft infrastructure. Infrastructure development is a fundamental element of national, provincial and municipal government economies as it is a catalyst to economic growth (Estache & Garsous, 2012). Investment in these infrastructure components would require both significant financial and political commitment by states and the private sector. In addition, cross-border co-operation regarding infrastructure investment by regional financial institutions and FDI will play a critical role (Ismail, 2018).

In the year 2000, it was estimated that Africa requires an annual investment of circa US$93 billion to subsidize its economic activity, with one third of the outlay reserved for maintenance (Kodongo & Ojah, 2016). The required investment is larger than the economies of most African countries, which makes it *ipso facto* unaffordable. The majority of African countries have substantial debt and deficit challenges, which compound the sluggish infrastructure development that is witnessed today (Calderón, Cantú, & Chuhan-Pole, 2018). Funds that governments raise through taxes are primarily committed to servicing high interest rates of debt payments and, as a result, are not available for the financing of infrastructure development. This is further exacerbated by high debt levels, which lead to low credit ratings. Low credit ratings discourage FDI and inhabits the ability of governments to borrow, leaving them with inadequate public purses collected through taxes to cover their infrastructure gaps.

Over the last decade, the African continent has experienced more and more reduced FDI (Ajayi, 2006), (UNCTAD, 2020). This results in the loss of opportunity to leapfrog production output, increase taxes and increase economic growth. FDI has instead increased in developed and emerging countries in Europe and Asia (Ajayi, 2006), (UNCTAD, 2020). With the African economy growing more rapidly than the rest of the world, Africa needs to make ongoing investments in new infrastructure to accommodate her growth (Calderón, 2009). Additionally, in order for African countries to maximise the AfCFTA benefits, they need to build the necessary infrastructure to facilitate and ease trade.

### 1.2 Research problem and research question

The African continent currently has the highest level of poverty in the world (Ajayi, 2006). The World Bank estimates that most African households live on less than US$1 per day. AFCTA has been identified as one of the opportunities that can alleviate poverty through industrialisation and creation of regional value chains. Free trade, however, requires the support of infrastructure development to maximise its benefits across the regions.

Currently, Africa has a notable infrastructure deficit and falls way behind the rest of the globe when it comes to infrastructure progress (Jerome, 2011). The African continent's stagnancy has in fact been a significant contributor to its lack of infrastructure development and the decline of

existing infrastructure (Jerome, 2011). Africa has undergone a modest boost in infrastructure, particularly in the telecommunications (telecoms) arena (Jerome, 2011). The lack of and/or inferior preservation of the prevailing infrastructure has left it in a dire state, to the detriment of the continent's economic advancement (Jerome, 2011).

Infrastructure development has been found to be *sine qua non* to economic growth (Rupa & Foster, 2011). Therefore, in order for African countries to flourish, they need to invest in their infrastructure growth. A government that maintains its infrastructure is considered a bedrock facilitator for economic prosperity and productivity (Fullerton, Monzón, & Walke, 2013). Local infrastructure inclines serves to enhance growth and can reduce costs for both social-housing development and industrial businesses (Estache & Garsous, 2012). Permitting infrastructure deterioration limits the ability to keep up with the growth rate, which can potentially cause costly bottlenecks and erode private-sector capacity (Rupa & Foster, 2011) .

It is estimated that infrastructure development in Sub-Saharan Africa (SSA) accounted for 99 basis points of the gross domestic product (GDP) per capita from 1999 to 2005 (Africa Infrastructure Country Diagnostic, 2009). The lack of infrastructure results in a higher return for a small investment (Kodongo & Ojah, 2016). It is estimated that infrastructure development has contributed to 50% of Africa's improved performance and an average GDP growth of 4% from 2000 – 2005(Africa Infrastructure Country Diagnostic, 2009). Two of the fastest-growing economies in the East Asian region, China and Vietnam, are estimated to invest circa 10% of their GDP towards infrastructure. Despite this, their infrastructures are still struggling to keep up with the growing pace of their economies (Straub, Vellutini, & Warlters, 2008). In 2008, the Greater Mekong countries – Laos, Cambodia, Thailand, Vietnam, Myanmar, and China – intended to grow their GDPs by at least 5 to 6% annually. At the centre of their objectives was infrastructure development, which endeavoured to integrate the energy and transport infrastructures (Straub et al., 2008). The infrastructure plan seems to have worked for China as it unlocked that country's industrialisation value chain and placed it as one of the top five biggest economies. Africa should take lessons from countries like China and prioritise investment in infrastructure.

Kodongo and Ojah (2016) found that it is the investment in infrastructure and its increments that significantly boost the economic growth of a country. The significance of such investments has been found to be greater for lesser-developed countries than more developed nations (Kodongo & Ojah, 2016).

To alleviate poverty, the African continent needs to make investments that are going to stimulate and enable increased economic activity, which can snowball into industrialisation and job creation. Given the limited resources emanating from a low-revenue purse, reduced FDI and high debt crisis, Africa needs to prioritise spending in areas that can unlock value and leapfrog its economic growth. There are two types of infrastructure, as defined, productive (hard) infrastructure (logistics, energy, telecoms and W&S) and soft infrastructure (education, health, residential and human development). Hard infrastructure is key as it comprises productive assets that are catalysts to the development of soft infrastructure. Out of all the infrastructure components, which ones should African countries prioritise? Which component can unlock value and potentially contribute significantly to economic growth?

### 1.3 Research objectives

The purpose of this research is to:

- Assess infrastructure progress across 10 countries in SSA;
- Examine the effect of different infrastructure investments on economic growth across 10 Sub-Saharan African countries.

### 1.4 Scope and Justification of the study

African countries are challenged by high poverty levels, unemployment rates, lack of human capital development and low GDPs per capita. The governments need to be informed about how to expand economic productivity and efficiency to stimulate economic growth, employment and empower human capital. This study will aid governments and policy makers in decision making relating to the prioritisation of monetary resources to reduce poverty, boost economic growth and create employment. Ten African countries have been selected based on the availability of data and previous studies on these nations.

## 1.5 Organisation of the study

This study is comprised of five chapters, as follows: Chapter 1 is a research proposal which answers the research problem, area and objective. Chapter 2 provides a review of literature on infrastructure development and its contribution to the economic growth of various countries. Chapter 3 presents the methodology, which entails the strategy carried out in collecting, analysing and measuring the data of factors that contribute to a country's GDP. Chapter 4 presents the results of the models discussed. Conclusions and recommendations of the study and future research are presented in Chapter 5.

# Chapter 2

# Literature review

## 2.1 Introduction

This chapter presents an overview of infrastructure development in selected countries, the theoretical framework on infrastructure development in relation to economic growth, empirical literature that studied how infrastructure development components contribute to economic growth and a chapter summary.

## 2.2 Infrastructure development in selected countries

This section seeks to highlight infrastructure development per capita in selected countries. The selected countries are Angola, Egypt, Ghana, Kenya, Morocco, Niger, Nigeria, South Africa (SA), Mozambique and Tanzania.

### 2.2.1 Population and GDP – 2019

Population relates to increase in the number of people, GDP relates to the growth in the Gross Domestic Product of each country. Population and GDP for each country in 2019 was as follows:

**TABLE 2. 1: COUNTRY POPULATION AND GDP FOR THE YEAR 2019**

| No. | Country | Population – 2019 | US$ GDP (billion) – 2019 |
|---|---|---|---|
| 1 | Angola | 31,825,000 | 126,506 |
| 2 | Egypt | 99,500,000 | 355,000 |
| 3 | Ghana | 30,418,000 | 58,996 |
| 4 | Kenya | 47,900,000 | 99,400 |
| 5 | Morocco | 36,472,000 | 109,709 |
| 6 | Mozambique | 30,366,000 | 12,652 |
| 7 | Niger | 23,311,000 | 8,120 |
| 8 | Nigeria | 200,964,000 | 375,770 |
| 9 | South Africa | 58,558,000 | 348,872 |
| 10 | Tanzania | 58,006,000 | 52,090 |

*Source: United Nations Data (2020 Publication)*

Based on the above data obtained from the United Nations, it is clear that the countries with the largest populations are Nigeria and Egypt, while the biggest economies per GDP are Nigeria, Egypt and SA followed by Angola, Morocco and Kenya. Niger has the smallest population and

economy; the smaller economy can be attributed partially to its landlocked state as compared to the rest of the coastal countries. Landlocked countries automatically have a disadvantage of limited access to coastal logistics by nature.

### 2.2.2 ICT infrastructure development

ICT infrastructure relates to the development of infrastructure for connection of mobile phones, telephone lines and internet access. An overview of ICT infrastructure development per capita from the year 2000 to 2015 for the selected countries has developed as follows:

**TABLE 2. 2: ICT INVESTMENT PER CAPITA**

| No. | Country | 2015 | 2010 | 2005 | 2000 |
|---|---|---|---|---|---|
| 1 | Angola | 11,78 | 5,79 | 0,12 | - |
| 2 | Egypt | 33,95 | 29,95 | 1,38 | 0,01 |
| 3 | Ghana | 22,07 | 6,89 | 0,20 | - |
| 4 | Kenya | 29,94 | 9,06 | 0,23 | - |
| 5 | Morocco | 40,10 | 28,78 | 2,55 | 0,02 |
| 6 | Mozambique | 11,18 | 3,15 | 0,09 | - |
| 7 | Niger | 5,95 | 1,75 | 0,03 | - |
| 8 | Nigeria | 25,45 | 9,62 | 0,24 | - |
| 9 | South Africa | 76,94 | 26,89 | 1,24 | 0,08 |
| 10 | Tanzania | 10,43 | 4,03 | 0,11 | - |

*Source: Africa Infrastructure Development Index (AIDI), 2020*

In the 2000s, ICT infrastructure was close to non-existent as it was dominated largely by telephone lines, which was driven by state investment. The increased use of mobile phones, which is driven by the private sector in Sub-Saharan Africa over the last decade, has seen a significant investment in mobile phone infrastructure – towers. Fibre network infrastructure investment is still very low. Based on the above, it is evident that SA, Egypt and Morocco are the leading investors, while Niger, Mozambique and Tanzania are the lowest contributors.

### 2.2.3 Power infrastructure development

Power infrastructure development relates to the developments of power generation and distribution infrastructure. An overview of power infrastructure development from year 2000 to 2015 for the selected countries is as follows:

**TABLE 2. 3: POWER INFRASTRUCTURE INVESTMENT PER CAPITA**

| No | **Country** | **2015** | **2010** | **2005** | **2000** |
|---|---|---|---|---|---|
| 1 | Angola | 6,40 | 4,60 | 2,75 | 1,63 |
| 2 | Egypt | 32,77 | 31,92 | 25,88 | 20,43 |
| 3 | Ghana | 6,94 | 7,58 | 5,77 | 7,03 |
| 4 | Kenya | 3,49 | 3,31 | 3,00 | 2,33 |
| 5 | Morocco | 14,23 | 13,09 | 11,55 | 7,80 |
| 6 | Mozambique | 12,04 | 12,72 | 11,66 | 9,82 |
| 7 | Niger | 0,30 | 0,18 | 0,17 | 0,16 |
| 8 | Nigeria | 2,72 | 2,82 | 2,92 | 2,04 |
| 9 | South Africa | 74,86 | 88,68 | 89,24 | 82,56 |
| 10 | Tanzania | 1,82 | 1,93 | 1,52 | 1,22 |

*Source: Africa Infrastructure Development Index (AIDI), 2020*

SA has been intensive in its investment in power infrastructure and is the biggest contributor to the growth, followed by Egypt, Morocco and Mozambique. Niger, Nigeria and Tanzania have invested very little into their power infrastructure. Power infrastructure is, however, subjective as investment is dependent on the economic drivers of a country – mining and industrial economies require more power than agricultural economies. For example, South Africa, Nigeria and Angola, with their high natural resources, require more power than Niger and Kenya, whose economies are driven largely by agriculture.

### 2.2.4 W&S infrastructure development

W&S infrastructure development relates to the development of water catchments, dams, sanitation and distribution infrastructure. An overview of W&S infrastructure development per capita from year 2000 to 2015 for the selected countries is as follows:

**TABLE 2. 4: W&S INFRASTRUCTURE INVESTMENT PER CAPITA**

| **No.** | **Country** | **2015** | **2010** | **2005** | **2000** |
|---|---|---|---|---|---|
| 1 | Angola | 40,14 | 46,09 | 40,48 | 34,59 |
| 2 | Egypt | 97,89 | 99,01 | 97,31 | 92,41 |
| 3 | Ghana | 52,47 | 49,70 | 43,65 | 36,89 |
| 4 | Kenya | 40,62 | 39,06 | 35,18 | 32,03 |
| 5 | Morocco | 79,02 | 75,13 | 71,98 | 68,56 |
| 6 | Mozambique | 27,11 | 23,49 | 1,06 | 17,90 |
| 7 | Niger | 27,89 | 20,50 | 18,33 | 14,45 |
| 8 | Nigeria | 44,05 | 37,84 | 37,61 | 35,71 |
| 9 | South Africa | 79,99 | 85,35 | 82,92 | 79,76 |
| 10 | Tanzania | 28,16 | 23,88 | 24,60 | 24,11 |

*Source: Africa Infrastructure Development Index (AIDI), 2020*

All countries have made a substantial investment into their respective W&S infrastructures, with the lead investors being SA, Egypt and Morocco. Despite Niger being a smaller economy, it has managed to be on par with Mozambique and Tanzania in 2015.

### 2.2.5 Transport infrastructure development

Transport infrastructure development relates to the developments of airport, seaport, road and rail infrastructure. An overview of transport infrastructure development per capita from the year 2000 to 2015 for the selected countries is as follows:

**TABLE 2. 5: TRANSPORT INFRASTRUCTURE DEVELOPMENT PER CAPITA**

| No. | Country | 2015 | 2010 | 2005 | 2000 |
|---|---|---|---|---|---|
| 1 | Angola | 1,87 | 2,10 | 2,33 | 2,65 |
| 2 | Egypt | 56,75 | 55,03 | 54,10 | 50,84 |
| 3 | Ghana | 12,41 | 12,60 | 7,04 | 6,54 |
| 4 | Kenya | 12,09 | 4,75 | 5,00 | 5,02 |
| 5 | Morocco | 9,43 | 9,77 | 9,16 | 8,92 |
| 6 | Mozambique | 2,02 | 1,92 | 1,95 | 2,15 |
| 7 | Niger | 1,88 | 2,05 | 2,24 | 1,52 |
| 8 | Nigeria | 5,08 | 5,07 | 5,20 | 5,38 |
| 9 | South Africa | 21,91 | 12,94 | 13,27 | 15,04 |
| 10 | Tanzania | 3,27 | 3,16 | 2,65 | 3,14 |

*Source: Africa Infrastructure Development Index (AIDI), 2020*

Egypt is the lead investor in transport infrastructure as is evident from its investment from 2000 – 2015, while the remainder of the countries have made minor to no investment. SA, Ghana and Morocco have made some investments, but on a considerably smaller scale than Egypt's investment.

Overall, South Africa, Egypt and Morocco have been intent on their investment into infrastructure development as they are consistently in the lead as compared to other countries. All countries have made a deliberate decision to invest in their W&S infrastructure as it is the only component where there is a clear per-capita alignment. Nigeria, despite being the biggest economy per GDP, is constantly on the backfoot with trivial or no investment on certain infrastructure components, except for W&S. In addition, given Nigeria's population size and oil reserves, it is expected that it should lead investment to support its economic activities. The

subordinate investment by Niger is expected as it has a smaller economy with a smaller population and the disadvantage of being landlocked.

### 2.2.6 Human Development Index (HDI)

Human development index refers to the development of people through education, health and income earnings. An overview of HDI per capita from the year 2000 to 2015 for the selected countries is as follows:

**TABLE 2. 6 HUMAN DEVELOPMENT INDEX PER CAPITA**

| No | Country | 2015 | 2010 | 2005 | 2000 |
|---|---|---|---|---|---|
| **1** | Angola | 0,565 | 0,51 | 0,453 | 0,394 |
| **2** | Egypt | 0,69 | 0,666 | 0,635 | 0,611 |
| **3** | Ghana | 0,585 | 0,554 | 0,508 | 0,483 |
| **4** | Kenya | 0,562 | 0,533 | 0,484 | 0,446 |
| **5** | Morocco | 0,66 | 0,618 | 0,581 | 0,531 |
| **6** | Mozambique | 0,428 | 0,396 | 0,354 | 0,301 |
| **7** | Niger | 0,36 | 0,319 | 0,283 | 0,253 |
| **8** | Nigeria | 0,527 | 0,484 | 0,467 | 0,47497 |
| **9** | South Africa | 0,699 | 0,662 | 0,62 | 0,629 |
| **10** | Tanzania | 0,519 | 0,487 | 0,442 | 0,395 |

*Source: Africa Infrastructure Development Index (AIDI), 2020*

South Africa, Morocco and Egypt lead the HDI per capita while Niger and Mozambique lag behind the remainder of the countries. Overall all countries have invested in improving the HDI of their residents. The improvement in education could be linked to access to mobile phones and internet which provides cheaper education.

### 2.2.7 Employment

Employment relates to the creation of jobs and opportunities for development of Small, Medium and Micro-enterprises which is a biggest source of income in majority of the African countries. An overview of Employment per capita from the year 2000 to 2015 for the selected countries is as follows:

**TABLE 2. 7 EMPLOYMENT PER CAPITA**

| No | Country | 2015 | 2010 | 2005 | 2000 |
|---|---|---|---|---|---|
| **1** | Angola | 72,10 | 70,11 | 61,04 | 59,24 |
| **2** | Egypt | 41,71 | 43,46 | 41,34 | 41,97 |
| **3** | Ghana | 75,06 | 72,10 | 71,81 | 66,93 |
| **4** | Kenya | 57,99 | 57,96 | 58,02 | 63,62 |
| **5** | Morocco | 44,34 | 45,34 | 45,21 | 44,06 |
| **6** | Mozambique | 59,01 | 63,65 | 66,62 | 66,64 |
| **7** | Niger | 78,72 | 78,47 | 76,57 | 77,11 |
| **8** | Nigeria | 52,72 | 52,82 | 52,40 | 52,63 |
| **9** | South Africa | 40,90 | 39,43 | 40,82 | 40,68 |
| **10** | Tanzania | 81,60 | 80,65 | 79,40 | 78,96 |

*Source: Africa Infrastructure Development Index (AIDI), 2020*

Tanzania, Niger, Ghana and Angola lead the employment per capita stats. Big economies lag behind – South Africa, Egypt, Morrocco and Nigeria. Majority of the countries have experienced menial improvement in the stat, while Egypt and Mozambique have a mixture of improvement and deterioration. Africa's largest source of employment is SMMEs, hence smaller economies thrive as there are no other job opportunities but to simply become an entrepreneur with earning that are below a living wage. Biggers economies have poor stats as residents are educated and sometimes wait for some time to obtain employment. Safe for Covid -19, the new global pandemic, the continent's life expectancy is expected to improve in the future years.

### 2.2.8 Life Expectancy per capita

Life expectancy refers to the average number of years people are expected to live from birth to mortality. An overview of Life expectancy per capita from the year 2000 to 2015 for the selected countries is as follows:

**TABLE 2. 8 LIFE EXPECTANCY PER CAPITA**

| No | Country | 2015 | 2010 | 2005 | 2000 |
|---|---|---|---|---|---|
| **1** | Angola | 61,76 | 60,32 | 57,80 | 53,83 |
| **2** | Egypt | 87,50 | 86,88 | 85,15 | 82,24 |
| **3** | Ghana | 63,91 | 60,80 | 72,83 | 59,62 |
| **4** | Kenya | 70,75 | 67,30 | 63,14 | 62,28 |
| **5** | Morocco | 84,59 | 83,59 | 82,29 | 81,18 |
| **6** | Mozambique | 64,74 | 62,00 | 56,01 | 52,71 |
| **7** | Niger | 70,66 | 69,50 | 67,12 | 57,44 |
| **8** | Nigeria | 61,98 | 61,20 | 58,33 | 55,08 |
| **9** | South Africa | 67,87 | 64,91 | 61,49 | 66,51 |
| **10** | Tanzania | 69,53 | 68,35 | 63,54 | 60,00 |

*Source: Africa Infrastructure Development Index (AIDI), 2020*

The residents of Egypt and Morocco live longer with an average life expectancy of more than 80years. The remainder of the countries have low life expectancies averaging just over 60 years. The life expectancies of Africa have been impacted by a myriad of pandemics, some with no vaccines nor cures such as HIV & AIDS, Ebola, Malaria, tuberculosis and other water born diseases. The impact is evidenced in the stats as Sub-Saharan countries, which was impacted mostly, have lower life expectancies than North African countries. Africa has conquered immensely in developing vaccines and cues over these pandemics.

## 2.3 Theoretical framework: infrastructure development and economic growth

Infrastructure development has anecdotally been documented as a catalyst to economic growth. There are two widely accepted infrastructure groups in the commercial industry: hard infrastructure and soft infrastructure (Luo & Xu, 2018). Hard infrastructure refers to power, transport (road, rail, sea and air), telecoms and W&S. Soft infrastructure, on the other hand, includes education, health and residential infrastructure (Luo & Xu, 2018). The focus of this research is on both hard and soft infrastructure's contribution to economic growth due to their overlapping effect.

Hard infrastructure is often referred to as productive infrastructure due to its immediate contribution to economic activities. For example, the availability of power can result in increased production output due to the stability to manufacture, logistics infrastructure can reduce production costs immediately, telecommunications infrastructure can connect a company to the

world and therefore enable international sales and, lastly, access to W&S can result in improved health. These infrastructure components are preferred for investment purposes as they pay for themselves over time through their contributions to the GDP.

In contrast, soft infrastructure focuses more on the labour aspect of the economic activity. Education infrastructure will improve human capital development and upskills the labour required to participate in the economy. Health and residential infrastructure will ensure the well-being of labour and contributes indirectly to economic growth through reduced interruptions caused by absenteeism. Soft infrastructure development therefore complements hard infrastructure, the two are not mutually exclusive. Economists encourage countries to develop their hard infrastructure first in order to afford the development of soft infrastructure. The dependent relationship of both hard and soft infrastructure is further supported by the endogenous growth model were countries with a combination of large human capital stock and an open free international trade were found to experience faster growth rates (Romer, 1990).

The theory of infrastructure development-led growth recognises investment in public infrastructure as the engine to economic growth (Agénor, 2006). Agénor (2006) identifies what is termed a network effect between infrastructure development and economic activity. For example, a government that invests in health infrastructure experiences increased labour activity through a reduction in absenteeism. Increased productivity leads to increased value in capital stocks, savings, taxes, etcetera. The network effect will enable an efficient infrastructure-investing government to realise multiple equilibrium growth paths (Agénor, 2006).

Holding all things equal, economies that lack hard infrastructure development are poor and stagnant in their economic growth as they have high production costs. Infrastructure development unlocks value and enables countries to participate in global trade and industrialisation. For example, a country with a stable and sufficient supply of power is likely to attract FDI, which will lead to an increased GDP. This is evident from the reduced GDP growth of SA since the country started experiencing power cuts in 2008 and again in 2019 – 2020. Equally, W&S, telecoms and transport development generate increased FDI, trade and reduced transport costs, which drive improved economic activity. The benefits of a growing economy are enormous as

they have a larger and broader implication in improving levels of poverty, human capital development, education, health and most of the 17 sustainable development goals (SDG). The opposite has unfathomable implications which can lead to deterioration and hopelessness in a nation.

In the early 1960s post-World War II, the quality of life of European people had degraded so much that it became the focal point of economists (Aschauer, 1990). The persistence of social problems such as poverty, insufficient health care, lack of housing and environmental degradation motivated social scientists and economists to search for improved levels of living and appropriate institutions to respond to the challenge (Aschauer, 1990). Infrastructure development was identified as a catalyst to economic growth. The International Bank for Reconstruction and Development, which is now part of the World Bank Group, was formed specifically to finance infrastructure development in countries that formed part of the United Nations at the time (World Bank). The intense focus on infrastructure development studies began in the 1990s by authors like Aschauer (1990) who found a significant correlation between infrastructure development and economic growth. Aschauer (1990) found that infrastructure development was responsible for the significant improvement in the quality of life, health and economic opportunity. As such infrastructure development has played a vital role in the robust performance of many countries' economies worldwide during the Golden Age of Capitalism from about 1950 to the early 1970s.

Barro (1990) in his endogenous growth model states that the growth of a government is a result of the amount of investments it is willing to invest in its economy and not from external investments. Barro (1990) found that a government that invests in its economy and people is likely to experience high returns through high production, taxes, savings, utilities and improved skills, which improve the GDP.

Theoretically, there are three primary and widely accepted schools of thought on how infrastructure contributes to economic growth. The first view argues that infrastructure quality has a direct impact on the country's output, which flows directly into its economic growth basket (Aschauer, 1993). The second view makes the case that infrastructure development improves

production efficiency, lowers cost and increases manufacturing companies' productivity (Barro, 1990). The third school of thought defends the idea that infrastructure development creates jobs and improves education and health care, which contributes to better performance of entities that contribute to economic growth (Fedderke & Garlick, 2008). The schools of thoughts are supported by an anecdotal plethora of evidence which proves that infrastructure development is key to economic growth, hence the United Nations' focal point post World War II to rebuild infrastructure.

## 2.4 Empirical literature: Infrastructure development and economic growth

Over the past 20 years, resources have been ploughed into this subject in an attempt to determine the impact of infrastructure development on economic growth. A plethora of empirical evidence, which is discussed below, confirms the correlation between infrastructure development and economic growth. The World Bank estimates that for every US$1 investment in infrastructure, an average government worldwide can yield a return of US$4 over the years.

Rupa and Foster (2011) completed a study which assessed the impact of infrastructure development on economic growth in 15 Southern African Development Community (SADC) member nations over a 10-year period (1995 – 2005). The study concluded that infrastructure development in the SADC region boosted economic growth by up to 1.2% points per capita (Rupa & Foster, 2011). The study further emphasised the importance of regional infrastructure integration to achieve maximum growth and provide support to landlocked and smaller countries (Rupa & Foster, 2011). Rupa and Foster (2011) attributed most of the growth to ICT's increase in mobile phone and electrical power integration. In addition, the research concluded that infrastructure development is *sine qua non* to economic growth (Rupa & Foster, 2011). Sanctioning the decline of infrastructure limits the ability to keep up with the rate of growth, which can give rise to costly bottlenecks and diminish private-sector productivity (Rupa & Foster, 2011).

Fullerton et al. (2013) researched the impact of infrastructure development on economic growth on a single metropolitan area in the USA – El Paso, Texas – using time-series data collected over 34 years. The study concluded that infrastructure development interrupts short-run economic

growth but contributes to it over a long run (Fullerton et al., 2013). The research found that the economic growth of a metropolitan region is hindered during a construction period and promptly restarts post-completion of major construction (Fullerton et al., 2013). A government that maintains its infrastructure is regarded as a foundation enabler for economic growth and productivity (Fullerton et al., 2013).

Calderón (2009) completed a research on the effect of infrastructure development on economic growth over a sample of 39 African countries for a period of 15 years. The study used econometric techniques for dynamic panel data to complete the study. Calderón (2009) found that an increase in infrastructure stock quality and service boosted economic growth by a growth pay-off of 1.1% in North Africa and 2.2% in SSA. The author further concluded that the African continent is likely to gain further from increased infrastructure than enhancement of existing infrastructure (Calderón, 2009).

Calderón et al. (2018) surveyed 45 Sub-Saharan African countries and the relationship of their infrastructure development in relation to economic growth. The results showed that infrastructure continues to be a bottleneck in SSA and if the gap was closed, the economy of those nations could swell to 1.7% GDP per capita annually (Calderón et al., 2018). With most SADC countries facing infrastructure decline and less than 0.5% growth in GDP investment, infrastructure is indispensable to their GDP growth.

Kodongo and Ojah (2016) researched whether infrastructure development explains economic growth on a panel data of 45 Sub-Saharan African countries over an 11-year period (2000 – 2011). Kodongo and Ojah (2016) found that it is the investment in infrastructure and its increments that has considerably uplift a country's economic growth. The investments have been found to provide greater bolstering for lesser-developed countries than more developed nations (Kodongo & Ojah, 2016). In addition, infrastructure quality and the access to it increases economic growth further indirectly through diversified export opportunities, trade enablement and cross-border capital flows (Kodongo & Ojah, 2016). Thus, there is no doubt that a further investment in the development of Africa's infrastructure will result in significant growth.

In its African research, the Africa Infrastructure Country Diagnostic (2009) selected 24 African countries that contribute 85% to the continent's GDP and population. The study concluded that infrastructure development in Sub-Saharan Africa made up 99 basis points of GDP per capita from 1999 to 2005. The authors further concluded that infrastructure development has been responsible for 50% of Africa's improved performance and an average GDP growth of 4% from 2000 –– 2005 (Africa Infrastructure Country Diagnostic, 2009).

Jerome (2011) researched the relationship between infrastructure, economic growth and poverty in SSA over a period of 15 years. The infrastructure variables in his study were access to landlines, piped water, flushing toilets and electricity (Jerome, 2011). Jerome (2011) found a positive linear relationship between infrastructure, economic growth and poverty reduction on the African continent. The study further compared Sub-Saharan infrastructure development to its counterparts -Asia, Europe and the Americas. It was concluded that SSA lags far behind them in infrastructure development, as lack of maintenance has led to a decrepit state of its existing infrastructure (Jerome, 2011). Currently, Africa has a sizeable infrastructure shortfall and lags far behind the rest of the world when it comes to infrastructure development (Jerome, 2011). Africa's static growth has furthermore been greatly attributed to its lack of infrastructure development and the deterioration of the existing infrastructure (Jerome, 2011). Africa has undergone a moderate improvement in infrastructure, especially in the field of telecommunications (Jerome, 2011). The lack of and/or poor upkeep of infrastructure has left the existing one in an alarming state to the detriment of the continent's economic growth (Jerome, 2011).

In a study of the infrastructure development impact on economic growth in East Asian countries, Straub et al. (2008) used both the growth accounting framework and the cross-country regression. The study failed to find a significant link between infrastructure development and economic growth (Straub et al., 2008). The review led the authors to conclude that infrastructure development does not directly encourage economic growth, but instead plays a key role in relieving bottleneck challenges and constraints. This, in turn, results in economic growth.

In a time-series analysis over 49 years, Perkins (2005) studied the impact of infrastructure development on economic growth in South Africa from 1960 – 2009. Perkins (2005) found that infrastructure development accounted for an average of 4% towards GDP. The study concluded that infrastructure development is a foundation to building the economy and enabling the facilitation of multiple economic activities (Perkins, 2005). Perkins (2005) found a positive linear relationship between infrastructure development and economic growth – GDP.

In a time series study which investigate the impact of Infrastructure development over regional growth in China for period 1990-2013, it was concluded that Infrastructure development effects growth, but over development of certain infrastructure components such as roads can have a negative effect on growth (Shi, Guo, & Sun, 2017).

Ogundipe, Oye, Ogundipe, & Osabohien,(2020) investigated the impact of Infrastructure absorptivity in attracting FDI during1995-2007 for ECOWAS countries. The study concluded that infrastructure development attracts FDI, which stimulate growth. Khan, Khan, Jiang, & Khan,(2020) concluded that infrastructure development effects economic growth, over a study of South Asian countries when adopting a pooled mean group estimation.

### 2.5 Empirical literature: Components of infrastructure investments and economic growth

There are four hard infrastructure components as defined by investors globally, namely power, telecom, transport and W&S. Each of these plays a role in contributing to economic growth. This section seeks to highlight each component's role per empirical literature.

#### 2.5.1 Power

The power infrastructure component relates to the power generation capacity of a country, kilometres of distribution lines and the amount of people who have access to power in a country. Estache and Garsous (2012) studied the impact of infrastructure development on economic growth over a group of developing countries in SSA, Latin America, Asia and Middle East & North African (MENA) countries. The survey found that SSA required 10% investment, Asia

and Latin America 4 – 5% and MENA 3% (Estache & Garsous, 2012) The research identified energy as a highly ranked component with an investment gap of 40 – 60% across all regions.

Yoo and Lee (2010) completed a cross-country study of 88 countries for the period 1975 – 2004, grouped between the Organisation for Economic Co-operation and Development (OECD), non-OECD, developing and non-developing countries. The study sought to determine the effect of electricity consumption on economic growth as the authors argued that power is the foundation of economic growth due to its catalytic role in the remaining infrastructure areas(Yoo & Lee,2010). The findings revealed a statistically significant relationship between per-capita income and per-capita consumption of electricity (Yoo & Lee, 2010).

Nyasha et al. (2018) in an Ethiopian time-series study between 1971 – 2013 sought to establish the relationship between energy consumption and economic growth. A significant relationship was established between the Ethiopian energy consumption and its economic growth, both in the short and long run (Nyasha et al., 2018).

Odugbesan and Rjoub (2020) researched the relationship between energy consumption, emissions and economic growth in MINT countries (Mexico, Indonesia, Nigeria and Turkey) from 1993 – 2017. The study found that a significant relationship existed. Chaudhry et al. (2012) in a time-series analysis for the period of 1972 – 2012 sought to establish the effect of electricity consumption on economic growth in Pakistan. The study concluded that electricity consumption significantly stimulates economic growth and GDP in Pakistan (Chaudhry et al., 2012).

Sharmin and Khan (2016) studied the effect of electricity consumption on economic growth in 26 African countries over a 25-year period. The study found a relationship between energy consumption and economic growth in different countries (Sharmin & Khan, 2016). A time-series annual data study from 1980 – 2010 over four South Asian countries, Bangladesh, Pakistan, India and Sri Lanka, sought to establish a relationship between electricity consumption and economic growth. It was concluded that there exists a long-run relationship between energy consumption and economic growth (Raza, Jawaid, & Siddiqui, 2016). Energy has been found to be

consequential as its purpose overlaps with the efficient functioning of the rest of the infrastructure components (Estache & Garsous, 2012).

### 2.5.2 Information Communication and Technology (ICT)

Koutroumpis (2006) conducted a study that sought to determine the effect of broadband penetration on economic growth over 15 European countries, based on data collected from the years 2003 – 2006. Utilising the macroeconomic production function, the review found a significant positive link between broadband growth and economic growth when infrastructure development reaches critical mass (Koutroumpis, 2006). Additionally, developed countries were found to be able to reach a critical mass point at a higher developmental stage as compared to under-developed economies (Koutroumpis, 2006). Koutroumpis (2006) found that OECD countries were able to attain higher growth from increased telecoms infrastructure development in comparison to non-OECD countries, as the OECD nations reached critical mass quicker.

Datta and Agarwal (2004) conducted a study to investigate a long-run relationship between telecoms infrastructure and economic growth over 22 OECD countries with data collected from 1980 – 1992. The outcome showed a positive correlation between telecoms infrastructure and real GDP growth per capita (Datta & Agarwal, 2004). The research further supported the critical mass characteristics as it found that telecoms infrastructure has diminishing returns: at an early stage of development a country is likely to attain higher returns, while at the mature stage of development the return ceases to be linear (Datta & Agarwal, 2004).

Lee et al. (2009) completed a study to examine the effect of increased mobile phone usage on economic growth in 44 Sub-Saharan countries from 1975 – 2006. The study found a significant positive correlation between economic growth and the growth of mobile phones in SSA (Lee et al., 2009). The study advocated for an increase in mobiles phones in SSA due to the affordability of the technology.

Using data from 1990 – 2001 for 63 developing countries, Sridhar (2007) investigated the effect of telecoms penetration on economic growth. Sridhar (2007) found a positive link between economic growth and an increase in landline and mobile phones. In addition, the author

concluded that economic growth occurs as a result of reduced variables and fixed costs of obtaining information (Sridhar & Sridhar, 2007). The decreased cost of obtaining information provides access to job opportunities, market prices, efficient production processes, access to both local and international markets (Sridhar & Sridhar, 2007). Luo and Xu (2018) found that internet and mobile phones were significant contributors to economic growth in a long run (1990 – 2004) in 45 Sub-Saharan African countries. Ding and Haynes (2006) examined the role of telecoms on economic growth in 17 regions of China over a 17-year period, being 1986 – 2002. The study identified telecoms infrastructure as one of the key factors that leapfrogged economic development and growth in China (Ding & Haynes, 2006).

### 2.5.3 Logistics (rail, road and ports)

Cigu et al (2018) examined the link between transport infrastructure, public-sector performance and economic growth over a long run. The study researched this link using 22 European Union countries from 2000 – 2014. The authors concluded that a long-run relationship existed between transport infrastructure development, public performance and economic growth. Boopen (2006) examined the effect of transport infrastructure development on economic growth over a sample of Sub-Saharan countries and the Small Island Development States (SIDS). Using both cross-sectional and panel data, both studies concluded that the development of transport infrastructure contributed to the economies of the countries in the study (Boopen, 2006).

In a time-series study to examine the effect of development of road and rail transport on economic growth in India, using data from 1970 – 2010, Pradhan and Bagchi (2013) concluded that expansion of road and rail infrastructure with capital formation can lead to substantial advancement in India. Hlotywa and Ndaguba (2017) researched the effect of road transport investment on economic development in South Africa from 1990 – 2004. The authors concluded that a long-run correlation existed between transport investment and economic growth.

### 2.5.4 Water & Sanitation (W&S)

In a survey to assess the impact of infrastructure development on economic growth in 15 SADC member countries over a 10-year period (1995 – 2005), Rupa and Foster (2011) found that the

evidence linking W&S to economic growth was tenuous as W&S is the sector with the strongest association with education and health. In an analysis of 45 Sub-Saharan African countries and the connection of their infrastructure development to economic development, Calderón et al. (2018) found that access to water improved from 51% to 71% in these states. Most of the improvement was seen in urban areas as opposed to rural regions (Calderón et al., 2018). Calderón et al. (2018) found a positive correlation between infrastructure and economic growth, with one of the variables being W&S.

### 2.5.5 Human Development Index (HDI)

GDP and HDI have been acknowledged as the measures of development across the globe by economist (Verma, Gaur, & Kant, 2020). In a research that sought to determine the impact of GDP to HDI in high and medium HDI economies for the period 1990-2017, it was concluded that GDP alone does not facilitate HDI, GDP growth should be accompanied by policies that target HDI growth (Verma et al., 2020).Bechtel (2019)(2018)concluded that there is a link between GDP and HDI among United Nations countries at a national level and a global level. Bechtel (2020) conclude that the American GPD alone predicts HDI.

In a study that sought to assess the impact of GDP per capita on HDI in 10 ASEAN countries during the period 2010-2016, it was concluded that economic growth make is probable to achieve high levels of HDI.

### 2.5.6 Employment

In a time series study which sought to determine the impact of labour markets adjustment on labour during the period 1988-2004, it was concluded that labour lagged behind GDP growth by at least a four year period (Akkemik, 2008). A panel data study over the majority of OECD countries from 1990 to 2013 concluded that labour reforms influenced the relationship between GDP and labour as it relates to waged labour than salaried labour(Brancaccio, Garbellini, & Giammetti, 2018).

### 2.5.7 Life Expectancy

A panel data study that sought to investigate the relationship between life expectancy and GDP over 18 countries during 1820-2005, it was found that the relationship is increasing and bowl-

shaped (Boucekkine & Diene, 2003). Jakovljevic et al (2020) investigated the impact of healthcare spending on real GDP rates by comparing the behaviour of real GDP rates before, during and after the 2008 global crisis between G7 countries against seven emerging markets countries. The study concluded that emerging markets continued to be resilient as compared to G7 countries (Jakovljevic et al., 2020). In a study that sought to investigate the impact of COVID19 lockdowns to fatality rates and GDP growth in the first three quarters of 2020 among 42 countries, it was conclude fatality rates and lockdown restrictions lead to lower GDP rates, which caught up in the 3rd quarter as the restrictions were eased (König & Winkler, 2021).

## 2.6 Conclusion

The validation that infrastructure development contributes to growth is evident and reinforced by research papers. Infrastructure development remains essential to the evolution of any economy, under-developed states are more likely to benefit more from this development through the alleviation of bottlenecks than developed nations (Estache & Garsous, 2012). Closing the infrastructure gap is therefore of utmost importance to the economic development of Africa and its people (Lakmeeharan, Manji, Nyairo, & Poeltner, 2020). Access to infrastructure and quality is directly associated with economic growth and indirectly connected through trade competitiveness and cross-border capital flows (Kodongo & Ojah, 2016).

The African continent needs an investment of circa US$31 billion per annum and GDP growth of at least 7% to meet its Sustainable Development Goals (Africa Infrastructure Country Diagnostic, 2009). Currently, the continent's infrastructure is funded largely from the public purse which is far too small to meet the goals. Ideally, global investors should be directing FDI to Africa due to its high returns on investment. The impediment, however, has been corruption, lack of governance, lack of policy reforms on infrastructure development and terrorism.

Furthermore, part of the reason for little to no progress in infrastructure development in Africa is due to the 1990 optimism steering the narrative that the private sector should invest in the development of infrastructure (Jerome, 2011). This popular belief did not yield any results, as Jerome (2011) found that only 20 – 25% of infrastructure development in developing countries could be attributed to private-sector investment, while Africa received less than 10% investment from the private sector. These findings clearly portray a picture that thrusts the duty of

infrastructure development onto the government of a country. The government of every state should be pivotal to driving infrastructure development (Jerome, 2011). The private sector will always focus on investment that has a direct reward for their business, hence the reason why telecoms benefitted from greater investments (Jerome, 2011). While a nation's government should be the primary investor, the private sector will continue to fill in the shortfalls where required.

Infrastructure constraints destroy competitiveness and make trading with goods and services to the global marketplace a challenge (African Union, 2012). The poorer the quantity and quality of infrastructure, the poorer the economic growth and population (Kodongo & Ojah, 2016). This study confirms the endogenous growth model and the network effect theories. Local infrastructure advancement tends to enhance progress and can reduce industrial-firm costs, as well as those of social housing development (Estache & Garsous, 2012).

# Chapter 3

# Methodology

## 3.1 Introduction

This chapter presents the research methodology and design that is used to explore the specific research questions of this study. This analysis is descriptive in nature as it seeks to describe the nature of the relationship between infrastructure development components and economic growth. It also seeks to explore which component the African continent should prioritise given the limited availability of funding available for financing infrastructure development.

## 3.2 Research approach

There are three widely accepted forms of research employed by educational institutions, namely the quantitative research method, qualitative research method and mixed methods (a combination of quantitative and qualitative). For this study, a quantitative research method was selected as it more aptly outlines the correlation between infrastructure development and economic growth.

## 3.3 Research design

### 3.3.1 Data and sample size

A sample of 10 African countries was selected for this study. The selected countries are:

- East Africa: Kenya and Tanzania
- West Africa: Nigeria, Ghana and Niger
- Central and Southern Africa: South Africa, Mozambique and Angola
- North Africa: Morocco and Egypt

This research required that we collate macro data for each country for the period 2000 – 2015. A country is included only if all the required years of the data was gathered. These countries were selected based on availability of data for a consistent period of 15 years. Due to limitation in infrastructure stock take in the African continent, the research focused on the latest available date over a 15 year period being 2000 to 2015. The secondary data was collected for physical public infrastructure – population, GDP per capita, transport infrastructure per capita, W&S infrastructure per capita, power infrastructure per capita, ICT infrastructure per capita, HDI

per capita, employment per capita and life expectancy. The dependent and independent variable data was collected from the Africa Infrastructure Development Index (AIDI), 2020 which is run by the African Development Bank. The population and GDP (2019) data was obtained from the United Nations data platform.

### 3.3.2 Regression model

There are three commonly used cross-country infrastructure growth models. The first, being the endogenous growth model by Barro (1990), which was used in the SSA research by Kodongo and Ojah (2016); the second is the Gross Metropolitan Product (GMP) model Aschauer (1990) which was used by Fullerton et al. (2013) and third is the Principal Component Analysis (PCA) model which was used by Calderón (2018). The endogenous growth model was selected for this study, the relationship hypothesis to be tested is as follows:

$$GDPPC_{i,t} = \beta_0 + \beta_1 T_{i,t} + \beta_2 P_{i,t} + \beta_3 ICT_{i,t} + \beta_4 WS_{i,t} + \beta_5 HDI_{i,t} + \beta_6 E_{i,t} + \beta_7 LE_{i,t} + \varepsilon_{i,t}$$

Where GDPPC denotes Gross Domestic Product Per Capita, *i* and *t* denote country and year respectively, T represents Transport infrastructure per capita, P represents Power infrastructure per capita ICT represents ICT Infrastructure per capita, WS represents Water and Sanitation infrastructure per capita, HDI represents Human Development Index, E represents Employment and LE represents Life Expectancy. GDPPC is our dependent variable while T, P, ICT, WS, HDI, E and LE are the independent variables. The number of variables has been limited to the above seven based on available data and the key variables are explained further below.

### 3.3.3 Definition and measurement of variables

#### 3.3.3.1 GDP growth (dependent variable)

The dependent variable is GDP per capita. GDP in simple terms is defined as a monetary value measure of goods and services that are produced in a country and sold both domestically and internationally (Callen, 2008). An increase in GDP therefore denotes an increase in economic activity. Increased economic activity requires increase supply of employment, HDI through skills, money supply, health care, tax income and infrastructure to support the economic activity.

As our selected countries have different population and land sizes – which directly impact available labour – a GDP per capita was selected as a fair measure for comparison purposes. GDP per capita is a measure of output of goods and services per person in a country (Callen, 2008).

#### 3.3.3.2 Transport infrastructure per capita (T)

Transport infrastructure encompasses the development of infrastructure to move goods and people via air, rail, ports and road. A number of empirical studies have found a positive correlation between transport infrastructure development and economic growth, Boopen (2006), Hlotywa and Ndaguba (2017), and Pradhan and Bagchi (2013). In SA, the development of the N4, a national road, was found to be responsible for improving poverty levels, HDI, employment, education and trade between SA and Mozambique (Khoza & Willemse, 2013). A positive effect of transport infrastructure on economic growth is therefore expected.

#### 3.3.3.3 Power infrastructure per capita (P)

Power infrastructure relates to the development of power generation capacity and distribution lines. Power is the foundation of all infrastructure as it enables the functioning of other infrastructure component (Estache & Garsous, 2012). Empirical studies have found a relationship between power and economic growth. Luo and Xu (2018) found that lack of power and access to it is an impediment to economic development, while Raza et al. (2016) found a relationship between power consumption and economic growth. Given that the African continent still lags far behind the rest of the world regarding access to power, it is expected that there will be a positive effect between power and GDP.

#### 3.3.3.4 ICT infrastructure per capita (ICT)

ICT infrastructure represents the development of Information and Communications Technology infrastructure such as mobile connection towers, fibre connection cables and telephone lines. With the Fourth Industrial Revolution on our doorstep, it is expected that development of this infrastructure will take the globe to its next level of discovery. Datta and Agarwal (2004) in a study of 22 OECD countries found a positive correlation between telecoms infrastructure

development and GDP growth. Lee et al. (2009) found a positive correlation between economic growth and the growth of mobile phones in SSA. It is expected that a positive effect will be found between ICT infrastructure and GDP.

#### 3.3.3.5 WS infrastructure per capita (WS)

WS infrastructure relates to the development of water and sanitation reservoirs, re-use and piping infrastructure. Research on climate change has highlighted fresh water as a resource that is likely to be scarce in the future due to the changing environment (United Nations). Rupa and Foster (2011) found a weak correlation between W&S and economic growth as W&S are more related to improvement in health and education. It is estimated that the lack of safe, drinkable water is responsible for a GDP contraction of 32% per annum on the African continent (Bartram, Lewis, Lenton, & Wright, 2005). It is therefore expected that there will be a positive effect between W&S and GDP.

#### 3.3.3.6 Human Development Index (HDI)

The HDI definition was first developed by the United Nations Development Programme (UNDP) in the 1990s (Noorbakhsh, 1998). It is calculated by taking into account five main components: longevity, health, income, education and access to resources (Noorbakhsh, 1998). Infrastructure development as a catalyst to economic growth translates into an increase in Gross National Production (GNP) (Noorbakhsh, 1998). An increase in GNP requires a support of labour with high longevity, health, education level and resources. An increase in GNP will result in increased income and money supply. The symbiotic relationship between GNP and GDP results in an interdependent connection between HDI and GDP (Noorbakhsh, 1998). In a study that sought to determine the relationship between GDP and HDI in India , over a 30year period from 1980-2010, it was found that HDI contributed to GDP by 0,018 (Khodabakhshi, 2011). It is expected that HDI will have a positive relationship with GDP.

#### 3.3.3.7 Life Expectancy (LE)

In the 1800s, the life expectancy of humans was averaged at 30 years and infant mortality was common globally (Riley, 2015). In the 2000s, the life expectancy of people increased to an

average of 67 years globally with an expected to rise to 77 years (Riley, 2015). Riley (2015) attributed this improvement to what he termed the health transition. A number of empirical studies conducted in the 1990s found a positive relationship between life expectancy and economic growth (Echevarría & Iza, 2006). Recent studies have, however, shifted away from that narrative and are rather augmented with today's lifestyle, which is resulting in non-monastic results. Echevarría and Iza (2006) found a correlation between LE and GDP in countries where there is no social security. The study showed that social security tends to reduce the labour force and enforces retirement at a certain age, which ultimately reduces active economic activity. Acemoğlu (2006) found an insignificant effect of LE on GDP initially and over a 40-year horizon. This study has a combination of countries with social and no social security, the majority with no social security. The results are therefore expected to yield a positive effect between LE and GDP.

#### 3.3.3.8 Employment (E)

Employment relates to both formal employment and informal employment opportunities that are created by increased economic activity. Employment has been found to lag behind economic growth by at least four periods (Akkemik, 2008). Consequently, there is a reliant relationship where GDP growth occurs first and employment increases behind it. Chiang et al. (2015) found a relationship between employment and GDP, where employment was often identified as an intermediary between construction activities and GDP. In this study, it is expected that there will be an effect between employment and GDP.

### 3.4 Estimation approach

Our data set represents longitudinal or cross-sectional time-series data (i.e. panel data) where the behaviour of GDP, transport, power, ICT, WS, HDI, LE and Employment are observed across time and countries. There are three types of estimation techniques: we can either fit a fixed effects model, random effects model and/or a mixed effects model to the data.

**Fixed effects** is an estimation technique that is used to estimate a model where there is a single true effect, meaning the variables are either constant or change at a constant rate (Borenstein, Hedges, Higgins, & Rothstein, 2010). The fixed effects analysis is used if the assessment includes

all possible levels of a factor (Keller, 2014). **Random effects** are suitable for data with variables that are not constant or change at a rate that is not constant and are assumed to have more than one single effect (Borenstein et al., 2010). In addition, random effects are used when differences across entities have some influence on the dependent variable (Torres-Reyna, 2007). The key distinction between random effects and fixed effects is therefore whether a correlation exists between the unobserved individual elements and the regressor in the model, and not whether the effects are stochastic or not (Torres-Reyna, 2007). **Mixed effects** is a model that is suitable for analysing data with a combination of fixed and random effects. Given that our panel data does not have single effect across variables, countries and years, a random effect models might be more suitable. We will conduct various tests to determine which model best suits our data.

### 3.4.1 Non-normality

Non-normality is a data analysis tool that is used to test whether the distribution of independent error variables is normal or not (Keller, 2014). Statistical procedures such as t-test, linear regression, Discriminant analysis, etcetera are highly dependent on a normally distributed data set for validity (Mohd Razali & Bee Wah, 2011). Violation of normality assumption result in unreliable and invalid interpretations and inferences (Mohd Razali & Bee Wah, 2011). There are three ways of testing data for normality: graphic methods (Boxplots, histograms and QQ plots), numerical methods (kurtosis indices, skewness, Doornik-Hansen, etcetera) and formal normality test (Mohd Razali & Bee Wah, 2011). For the purpose of this research, the Doornik-Hansen test will be utilised to test for normality.

### 3.4.2 Autocorrelation

An effective regression is one where error terms of variables are independent. Error terms that are correlated over a period of time are said to be serially correlated, which makes a regression ineffective (Keller, 2014). When error terms from adjacent time periods are correlated, then there is serial correlation in the error terms. Serial correlation in panel data models can cause the model results to be less efficient. An effective regression is one with random errors as opposed to predictable errors caused by correlation. To test for autocorrelation, we will be using the Wooldridge Autocorrelation test. If the result yields a serial correlation, a robust regression model that caters for autocorrelation will be applied.

### 3.4.3 Heteroscedasticity

Heteroscedasticity occurs when the variance of error on independent variables is not constant (Keller, 2014). Homoscedasticity refers to constant error terms. Heteroscedasticity increases the variance of the predicted variable, i.e. GDP. To test for homoscedasticity, we will use the Breusch-Pagan/Cook-Weisberg test on the Stata software. If the result confirms that heteroscedasticity exists in our data, a robust regression model that caters for heteroscedastic data will be applied.

### 3.4.5 Multicollinearity

Multicollinearity occurs when the independent variables are correlated to each other (Keller, 2014). Multicollinearity increases the variance of the predicted variable, i.e. GDP. To test the existence of multicollinearity, we will use the Stata software correlation matrix. If independent variables are found to be correlated, multiple regression models, excluding correlated variables, will be run and analysed.

# Chapter 4

# Discussion of findings

## 4.1. Introduction

This chapter sets out to apply the research approach and methodology outlined in Chapter 3. It starts by describing statistics of the sample data, follows with diagnostic testing to examine the robustness and validity of the model, estimates the correlation coefficient of the independent variables and ends with interpretation of the relationship, which informs the conclusion and recommendation as outlined in Chapter 5.

## 4.2 Descriptive statistics

The primary function of descriptive statistics is to provide a summary of measures and a sample of a study. In the case of this study, we had 160 observations comprised of a study of GDP – dependent variable and seven independent variables over 10 countries for 15 years. The data consisted of variables per capita from 2000-2015.The table below provides a brief summary of the variables and their measurements.

**TABLE 4. 1: DESCRIPTIVE STATISTICS**

| Description | GDP | Transport | Electricity | ICT | W&S | HDI | LE | E |
|---|---|---|---|---|---|---|---|---|
| Mean | 7,22 | 10,93 | 15,62 | 8,49 | 47,62 | 0,50 | 66,96 | 59,59 |
| Std dev | 0,93 | 15,05 | 24,92 | 14,14 | 25,47 | 0,11 | 9,64 | 14,82 |
| Min | 5,55 | 1,48 | 0,11 | 0,00 | 1,06 | 0,25 | 52,71 | -2,44 |
| Max | 8,93 | 57,52 | 93,56 | 76,94 | 99,01 | 0,70 | 87,50 | 81,66 |
| Observations | 160 | 160 | 160 | 160 | 160 | 160 | 160 | 160 |

*Note: GDP = Gross Domestic Product, ICT = Information and Communication Technology, W&S = Water and Sanitation, HDI = Human Development Index, LE = Life Expectancy, E = Employment. Source: Researcher's estimate based on panel data*

The dependent variable, **GDP**, has a mean point of 7.22, minimum 5.55 and a maximum of 8.93. Given the different sizes of the economies in the study, their GDP per capita is not too wide, this is also confirmed by a low standard deviation of 0.93.

**Transport infrastructure** yields a mean of 10,93, minimum of 1,48 and a maximum of 57,52. Angola and Niger have been experiencing deterioration in development of Transport Infrastructure while Nigeria, a country with the largest population in the sample, has one of the lowest Transport Infrastructure per capita with marginal growth in development over the years. The high standard deviation is a result of the wide gap between the minimum of 1.48 and maximum of 57.52.

**Power infrastructure**, a key enabler to other infrastructure components, has revealed a mean of 15.62 and a large standard deviation of 24.92. The results are not surprising as there is a wide gap between minimum of 0.11 and a maximum of 93.56, with the largest contribution by SA and Egypt and the least contributors being Niger, Angola and Nigeria. Despite the wide gap, Power Infrastructure development has been experiencing an upward trend from all countries.

**ICT infrastructure** yields a mean of 8.49, minimum of 0.00 and a maximum of 76.94. The minimum of zero is largely attributed to periods between 2000-2003 where majority of the countries had no ICT infrastructure safe for SA, Egypt and Morocco. ICT infrastructure investment was improved by the introduction of mobile phones and the decrease in mobile phone costs over time.

**W&S infrastructure** yields a mean of 47.62, minimum of 1.06 and a maximum of 99.01. All countries have made a considerable effort to invest in W&S over the study period. SA, Egypt and Morocco are the biggest contributors, while Niger, Tanzania and Mozambique are the least investors in W&S infrastructure.

The **HDI** yields a mean of 0.5, minimum of 0.25 and a maximum of 0.7. HDI has largely been lower in Mozambique and Niger, which are smaller economies with lower infrastructure development. The standard deviation is on the lower side at 0.11, highlighting that the rest of the sample is aligned, save for the two countries.

**LE** yields a mean of 66,9 years, minimum 52,71 years and a maximum of 87,5 years. Mozambique and Niger contributed to lower LE largely in the early 2000s. The standard deviation is on the high side at 9,64 years. The higher LEs are provided by the larger economies, i.e. SA, Egypt and Morocco.

**Employment** statistics yield a mean of 59.94, minimum -2.44 and a maximum of 81.66. The minimum of -2.44 related to Nigeria in 2015, it is suspected that the tumble is related to the political instability of 2014 when an ISIS group called Boko Haram kidnaped young girls from school. The employment rate has since improved significantly. Higher employment rates are experienced in smaller economies – Niger and Tanzania – whereas larger economies such as SA, Morocco and Egypt have low employment rates.

### 4.3 Multicollinearity results

Multicollinearity occurs when two or more of the explanatory variables are highly correlated, which can cause variances in the predicted variable, being GDP in this case. The results of the test for multicollinearity using the Stata software is presented in Table 4.2. At a 5% significance level, the correlation between the majority of the variables is not significant (<0.75) to indicate the existence of any multicollinearity. However, there are some noticeably high (>0.75) correlations between W&S and three variables, namely Transport, Employment and HDI. The dangers of running a regression on highly correlated variables is the influence the regression has on increasing the variance in the predicted variable. Given the multiple collinearity result, we will complete two regressions, one without W&S (Equation 1) and another with W&S, but excluding HDI, Transport and Employment (Equation 2).

**TABLE 4. 2: CORRELATION MATRIX**

| Description | GDP | Transport | Power | ICT | W&S | HDI | LE | E |
|---|---|---|---|---|---|---|---|---|
| GDP | 1.0000 | | | | | | | |
| Transport | 0.3715 | 1.0000 | | | | | | |
| Electricity | 0.6483 | 0.3558 | 1.0000 | | | | | |
| ICT | 0.4539 | 0.3168 | 0.3686 | 1.0000 | | | | |
| W&S | ***0.7797**** | ***0.7968**** | 0.6581 | 0.4272 | 1.0000 | | | |
| HDI | ***0.8506**** | 0.6273 | 0.5822 | 0.5649 | ***0.8805**** | 1.0000 | | |
| LE | 0.2663 | 0.6923 | 0.1403 | 0.3872 | 0.6802 | 0.5615 | 1.0000 | |
| E | -0.7017 | -0.5189 | -0.5801 | -0.4016 | ***-0.775**** | -0.6815 | -0.4370 | 1.0000 |

*Note: GDP = Gross Domestic Product, ICT = Information and Communication Technology, W&S = Water and Sanitation, HDI = Human Development Index, LE = Life Expectancy, E = Employment. Source: Researchers estimate based on panel data. *Significant >0.75.*

## 4.4 Model diagnostics

We have completed a model diagnostic test for Equation 1 and Equation 2. Our diagnostics covered a test for normality, heteroscedasticity, autocorrelation and an estimation technique test. The results for the two models are discussed in this section.

### 4.4.1 Equation 1

The results of normality, heteroscedasticity, autocorrelation and estimation technique tests for Equation 1 is presented in Table 4.3.

#### Normality results

We have completed a Doornik-Hansen test to test the panel data of Equation 1 for normality using Stata software. The Doornik-Hansen test for normality has a null hypothesis that states that our data is normally distributed. The results yield a p-value of 0.0000 which is significant as it is lower than the significance level of 0.05. We therefore reject the null and conclude that our data is not normally distributed.

#### Heteroscedasticity results

As discussed in the methodology chapter, heteroscedasticity occurs when error terms are not constant, which will result in prediction variances of the dependent variable. We used the

Breusch-Pagan/Cook-Weisberg test on Stata software with a null hypothesis that error terms are constant to test for heteroscedasticity. The results have yielded a p-value of 0.015 which is significant as it is less than an alpha of 0.05. We reject the null and conclude that heteroscedasticity exists.

### Autocorrelation test

Autocorrelation exists when error terms of variables are predictable as opposed to being random. Predictable error terms are caused by autocorrelation and cause regression inefficiencies. We tested for autocorrelation using the Wooldridge Autocorrelation test from the Stata software with a null hypothesis that states that there is no first order of autocorrelation. The results yield a p-value of <0.05. We therefore reject the null and conclude that our data is autocorrelated.

### Estimation technique results

We used the Hausman fixed random test on the Stata software to determine a suitable estimation technique for our data. The null hypothesis for the Hausman fixed random test is that the preferred model is a random effect estimation technique. The test yields a p-value of 0.9295 which is insignificant as it is above the 5% significance level. We therefore fail to reject the null and conclude that the variance of error in our data is random, which makes a random effect model more suitable for our data.

**TABLE 4. 3 DIAGNOSTIC RESULTS FOR EQUATION 1 (EXCLUDES W&S)**

| Test | Results | Decision |
|---|---|---|
| Doornik-Hansen normality test | $\chi^2$= 686.917<br>Prob>$\chi^2$ = 0.0000 | Data is not normally distributed |
| Heteroscedasticity-Breusch-Pagan/ Cook-Weisberg test | $\chi^2$= 5.84<br>Prob > $\chi^2$= 0.0157 | The data is heteroscedastic |
| Wooldridge autocorrelation test | F (1,9) =131.949<br>Prob > F = 0.0000 | The variables are autocorrelated |
| Hausman fixed random test | Prob>$\chi^2$ = 0.9295<br>$\chi^2$= 1.89 | Random effect model is a better fit |

*Source: Researcher's estimate based on panel data*

### 4.4.2 Equation 2

The results of normality, heteroscedasticity, autocorrelation and estimation technique tests for Equation 2 are presented in Table 4.4.

**Normality results**

The Doornik-Hansen test for normality on Stata software has a null hypothesis that states that our data is normally distributed. The results yield a p-value of 0.0000 which is significant as it is lower than the significance level of 0.05. We therefore reject the null and conclude that our data is not normally distributed.

**Heteroscedasticity test**

We used the Breusch-Pagan/Cook-Weisberg test on Stata software with a null hypothesis that error terms are constant to test for heteroscedasticity. The results yield a p-value of 0.4895 which is insignificant as it is above an alpha of 0.05. We therefore fail to reject the null and conclude that our data is homoscedastic.

**Autocorrelation test**

We tested for autocorrelation using the Wooldridge Autocorrelation test on Stata software with a null hypothesis that states that there is no first order of autocorrelation. The results yield a p-value of 0.000 which is <0.05. We therefore reject the null and conclude that autocorrelation exists.

**Fixed versus random effect test**

We used **Sagan-Hansen** overidentifying restrictions to test for model specification on the Stata software to determine a suitable estimation technique for our data. The test yields a p-value of 0.0016 which is significant as it is below the 5% significance level. We therefore reject the null and conclude that the fixed effect model is more suitable for our data.

**TABLE 4. 4: DIAGNOSTIC RESULTS FOR EQUATION 2**

| Test | Results | Decision |
|---|---|---|
| Doornik-Hansen normality test | $\chi^2(10) = 450.631$ Prob>$\chi^2$ = 0.0000 | The data is not normally distributed |
| Heteroscedasticity-Breusch-Pagan/Cook-Weisberg test | $\chi^2$ (1) = 0.48<br>Prob > $\chi^2$ = 0.4895 | The data is homoscedastic |
| Wooldridge autocorrelation test | F (1, 9) = 86.362<br>Prob > F = 0.0000 | The variables are Autocorrelated |
| Sargan-Hansen | $\chi^2(04)$ = 17.491<br>Prob > $\chi^2$ = 0.0016 | Fixed effect model is more suitable |

*Source: Researcher's estimate based on panel data*

### 4.5 Regression results

The regression results on the effect of the components of infrastructure on economic growth is presented in Table 4.5. The two equations described previously, which were estimated using random and fixed effects techniques, are both significant at 1% to confirm their fitness in explaining economic growth among the sample countries. Based on the model diagnostics, Equation 1 failed the test for normality, heteroscedasticity and serial correlation while Equation 2 failed the test for normality and serial correlation. Hence, the two models were estimated using the variance-covariance estimator options to correct and improve the efficiency and validity of our model.

For equation 1, which excludes **W&S**, the model overall is a good fit as it has an $R^2$ of 78.76%, which confirms that circa 78.76% of GDP is explained by the independent variables. The p-value is significant at 0.000 which is less than 5%, a further confirmation that the model is a good fit for the data. For equation 2, which excludes the **HDI, Transport & Employment**, the regression yields an $R^2$ of 65.67% which means 65.67% of GDP can be explained by our independent variables. The p-value of the model is less than 5%, which also indicates that the model is a good fit for the data.

#### Transport Infrastructure

The regression results show a negative coefficient of Transport which is insignificant at 1%, 5% and 10%. The results signify that investment in Transport Infrastructure does not explain

economic growth. The result contradicts the theoretical and empirical literature in which a significant relationship was established between Transport Infrastructure and GDP.

**Power Infrastructure**

The coefficient of Power Infrastructure (Electricity) is positive and significant (at 1% in Equation 1 and 5% in Equation 2) which indicates that investments in Power Infrastructure enhance economic growth. The results are not surprising as power is a catalyst to the development of other infrastructure components. The results are in line with a range of empirical literature in which Power Infrastructure was found to contribute significantly to economic growth (Nyasha et al., 2018). The lack of power infrastructure has been found to be a major impediment to economic growth on the African continent(Luo & Xu, 2018). In addition, investing in power was found to be the best way to achieve a high social rate of return (Estache & Garsous, 2012).

**Information and Communications Technology (ICT) infrastructure**

The coefficient of ICT investment is negative but insignificant in Equation 1 while a positive and significant coefficient is observed in Equation 2 at 5%. The results support the expectations that investment in ICT enhances GDP and are in line with findings of Lee and Gutierrez (2009) and Calderón (2009) who found a significant relationship between economic growth and the growth of mobile phones in SSA. The critical mass nature of ICT infrastructure tends to yield higher growth for OECD countries as compared to non-OECD countries, which could explain the insignificant results obtained in Equation 1 (Koutroumpis, 2006).

**Water and Sanitation Infrastructure (W&S)**

The coefficient of W&S is positive and significant at a significant level of 10% which means that investment in W&S infrastructure contributes to the improvement of GDP. The outcome is in line with the findings of Juma and Yee-Cheong (2005) who found waterborne diseases to be responsible for circa 1.3% contraction in economic growth.

**Human Development Index (HDI)**

The coefficient of HDI is positive and significant at a significance level of 1% which highlights the overbearing importance of investing in HDI to achieve high economic growth. The African continent will need to invest more in developing its human capital to maximise its economic growth. The investment includes education, health and improvement in poverty levels. The significant contribution is further cemented by a study which concluded that HDI contributes circa 18% to GDP (Khodabakhshi, 2011).

**Life Expectancy (LE)**

In Equation 1, LE has a positive coefficient and is insignificant at a significance level of 1%, 5% and 10%. The results signify that an increase in a population's LE does not explain enhancement of GDP. In a study seeking to establish LE's contribution to GDP, it was concluded that LE contributes to GDP only in countries that have no social security system (Acemoglu & Johnson, 2006). The study makes sense as a country with no social security system will result in pensioners working beyond the age of 65 with a continuous contribution to GDP.

On the other hand, a country with a social security system will require its pensioners to give the younger generation a chance while the older generation receives social grants. Given that our data had a combination of countries with and without social security systems, the majority of which are without it, our results are aligned with study (Acemoglu & Johnson, 2006). LE results in Equation 2 yield a positive coefficient that is significant at a significance level of 10%. The results mean that an increase in LE enhances GDP. The results are in line with a number of studies in the 1990s which found a significant relationship between LE and GDP (Echevarría & Iza, 2006). Recent studies, however, have found an insignificant relationship.

**Employment (E)**

Employment has a negative coefficient which is insignificant at 1%, 5% and 10%. The results mean employment does not explain GDP. The results are in line with a study that found a four period time lag between GDP growth and increased employment (Akkemik, 2008). The four-period time lag partially explains the insignificant relationship established in our results. The lack of significance in the results is misaligned to theoretical and empirical literature.

### TABLE 4. 5: REGRESSION RESULTS – ROBUST RANDOM EFFECT RESULTS

| Dependent variable: economic growth (GDP) | | | | | | |
|---|---|---|---|---|---|---|
| | **Random effect** | | | **Fixed effect** | | |
| | **W&S excluded (Equation 1)** | | | **HDI, Transport and Employment Excluded (Equation 2)** | | |
| | ***Coefficient*** | ***z*** | ***P>\|z\|*** | ***Coef.*** | ***t*** | ***P>\|t\|*** |
| **Constant** | 4.9387*** | 11.45 | 0.000 | 4.6983*** | 6.26 | 0.000 |
| **Transport** | -0.0047 | -0.79 | -0.431 | | | |
| **Electricity** | 0.0091*** | 3.13 | 0.002 | 0.0174* | 2.13 | 0.062 |
| **ICT** | -0.0000 | -0.03 | 0.980 | 0.0038** | 2.4 | 0.040 |
| **W&S** | | | | 0.0106* | 1.91 | 0.088 |
| **HDI** | 4.0018*** | 4.87 | 0.000 | | | |
| **LE** | 0.0027 | 0.25 | 0.806 | 0.0255* | 2.03 | 0.073 |
| **E** | -0.0002 | -0.1 | 0.919 | | | |
| Wald $\chi^2$ /*F* | 186.31 | | | 12.99 | | |
| Prob > $\chi^2$ | 0.000 | | | 0.0009 | | |
| R-squared | 0.7687 | | | 0.6567 | | |
| Countries | 10 | | | 10 | | |
| Observations | 160 | | | 160 | | |

*Note: GDP = Gross Domestic Product, ICT = Information and Communication Technology, W&S = Water and Sanitation, HDI = Human Development Index, LE = Life Expectancy, E = Employment; ***, ** and * denote significance levels at 1%, 5% and 10% respectively. Source: Researcher's estimate based on panel data*

# Chapter 5

# Conclusion and recommendation

## 5.1 Introduction

This chapter presents a summary of the conclusion of the study, makes recommendations to policy makers on which infrastructure investment should be prioritised to achieve economic growth given limited funding, and provides guidance on avenues for future studies.

## 5.2 Summary and findings of the study

The study examined the impact of infrastructure development on GDP across 10 Sub-Saharan African countries over a 15-year period from 2000 – 2015. A panel data approach was applied to two equations, using both random and fixed effect regression models on Stata software to test several relationships between the dependant variable – GDP – and seven independent variables: Transport, Power, Information and Communication Technology (ICT), Water & Sanitation (W&S), Human Development Index (HDI), Life Expectancy (LE) and Employment (E). The results confirm that infrastructure development impacts GDP, which is aligned with theoretical literature and empirical studies. Power, ICT, LE, HDI and W&S infrastructures were found to be impactful to growth in GDP, while Transport and Employment were found to have no impact.

Power and HDI are observed to be the greatest contributors to GDP as compared to the other variables. The results for Power are not surprising due to its catalytic role in enabling other infrastructure components to function. Access to power enables increased economic activity and attracts FDI. HDI is similarly imperative, as economic activity cannot proceed without skilled, educated and healthy labour.

The ICT results confirm the imperiousness of ICT as the globe welcomes the 4$^{th}$ industrial revolution. The selected countries ICT infrastructure is dominated by mobile phone connectivity which is funded by the private sector and regulated by the state. The result affirms that Public Private Partnership is key to funding ICT infrastructure.

LE and W&S speak to the availability of labour, which is essential for economic activity. Not only is W&S an essential necessity, it also contributes to reduced diseases and, in turn, increased productivity. LE is argued to have a different effect depending on whether a country has a social welfare system or not. The longer that pensioners continue to actively participate in the economy, the higher the contribution to economic growth. As most of the countries in our sample do not have the capacity to offer social grants, the results are in line with expectations.

Transport infrastructure and Employment were found to be non-impactful contributors to GDP. Seeing that all 10 countries invested in growing their transport and have been experiencing an increase in employment in the last 15 years and experienced growth in GDP, it means there were other determinants of the GDP surge than transport and employment. As it relates to Employment, it is estimated that the majority of Africans live on less than US$1 per day. It could be argued that the results are linked to cheap labour practices that allow employers to pay non-living wages.

### 5.3 Policy recommendations of the findings

HDI and Power have been observed to be more impactful GDP contributors than other variables. Given their significance, it is imperative that African governments and policy makers create frameworks and policies that enable investment in Power and HDI.

The results of our study have an implication on the infrastructure investment plans, fiscal policy, monetary policy and political policy. The recommendation has been structured according to the above four items.

1. Infrastructure investment plans

   Given that Power and HDI have been identified as significant contributors to growth, infrastructure investment planners in various countries will need to map out a long-term plan on how they are going to increase HDI development and Power generation. Included in the plan should be the following:

   - Annual objectives and funding requirements

- African continent power generation and distribution plan
- Like SADC, an African continent regional power sharing plan
- Early childhood development and vaccination plan
- Research plan on potential arrivals of pandemics which could be caused by climate change

2. Fiscal policy

   African governments, together with fiscal policy makers, should prioritise the allocation of budget to human development. Innovative ways to increase HDI include:

   - Allocating funding to vaccines that reduce diseases
   - Building of health and educational facilities
   - Improving the quality of education to reduce migration to international universities
   - Stimulating local economic activity to reduce the migration of skilled labour to other countries

3. Monetary policy

   Power infrastructure investments are large and often funded in US$ millions, which are often bigger than some African countries' fiscal budgets. Power infrastructure has historically been funded through a project finance model with the bulk of the funding originating from FDI. Considering that the power infrastructure investment is highly dependent on FDI, the following changes in monetary policies are suggested to attract FDI:

   - Provide tax relief and rebates for power infrastructure investment
   - Authorise independent power production on commercial and industrial scales using renewable energy
   - Create an enabling environment to fund Power infrastructure on a utility scale, using project finance models such as Build Operate and Transfer (BOT)
   - Create monetary policies that allow stabilisation of local currencies
   - Create monetary policies that allow dividend pay-outs in foreign countries

4. Political policy

   Political instability and insurgency have been identified as primary reasons for reduction in FDI and increased African diaspora. The African continent, rich in mineral resources, is believed to be the biggest exporter of minerals. Unfortunately, Africa does not only export minerals, but is also the biggest exporter of highly skilled labour. The African diaspora continues to look for a better life in other countries due to lack of opportunities in their motherlands. Developed countries are more welcoming to highly skilled migrants to help them grow their economies, which leaves the African continent with a low population of skilled labour. To achieve political stability, the following political changes should be adopted:

   - Democracy should not only be a policy, it must be practised. Free and fair elections should be respected
   - The AU members of state should hold each other accountable for peace and human crimes
   - Heads of state should not be allowed to govern for more than two terms of five years each

The AfCFTA agreement was assembled with an objective to industrialise the African continent and improve her manufacturing capabilities and trade. Africa will need to have an innovative plan to increase human development and increase power generation capacity in order to achieve these objectives.

### 5.4 Avenues for future studies

The study was limited overall by the availability of data from various countries, especially landlocked ones and those with smaller populations. Data was generally available for coastal states; which *ipso facto* have an economic trade advantage. The country sample therefore consisted primarily of coastal countries. The lack of availability of data had an impact on the selected variables, which resulted in variables such as quality of educational institution and residential homes not being included due to unavailability of data. The model itself suffered from endogeneity and did not take time effects in to account.

Future studies should aim to incorporate a balanced mix of landlocked and coastal nations to ascertain if the ranking of the variables would change. Alternatively, a separate study of landlocked countries should be completed for comparison purposes to determine if the GDPs of landlocked versus coastal states are significantly affected by the same variables. As it relates to the model instrumental variables or system GMM should be used for robustness checks, and reverse causalities test should be conducted to identify endogenous variables in the model. m

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