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Title: THE INFLUENCE OF ROAD NETWORK CENTRALITY ON FDI ATTRACTION IN AFRICA.

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The influence of road network centrality on FDI attraction in Africa

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Title: The Influence of Road Network Centrality on FDI attraction in Africa.

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Summary

Issues concerning infrastructure development have for long been of interest to policymakers across the globe. Africa is the least connected continent globally and the infrastructure gap is a major structural constraint to the full exploration of economic opportunities within the continent. A major hindrance to infrastructure development in Africa is the finances needed to fill the infrastructure gap. AIDA, PIDA, ICA and AfDB estimate that the continent requires approximately over 90 billion US$ annually for the next 2 decades. By facts, this gap is so high that individual state budgets cannot sole-handedly meet this demand. Private investments are still insufficient. All major institutions backed by research have shown the implications of a disjointed unconnected continent on economic development and regional integration. For instance, the cost of trading becomes 70% higher in land-locked countries due to a lack of opening up of these regions. About 70% goes to the cost of transport on the price of a commodity (Bond, 2016).

A view into African Union’s agenda 2063 for Africa; a key priority is to create a prosperous and integrated continent. Infrastructure development is considered as a bridge to achieving most of the strategies aimed at achieving integration.

Achieving infrastructural development and increased connectivity in the continent is not only a major aspiration for the African Union but also very important and central in achieving the Agenda 2030-sustainable development goals. The SDG target 9.1 calls for developing sustainable infrastructure that facilitates regional and cross-border integration for increased economic development and the well-being of humans. In 2013, the Africa Infrastructure Country Diagnostic results indicated that approximately 50% of the recent economic developments in Africa were accounted for by investments into infrastructure. Therefore, the importance of developing infrastructure cannot be understated.

Empirical studies on the effect of transport development on economic activities in the continent are important. Most studies previously done have majorly examined aspects of infrastructure quality and quantity. This research seeks to establish the level of influence that road network centrality has on foreign investment activity in Africa. Road network centralities help to show the level of utility of the road network and can predict future possible connections that once physically linked can have significant impact on the competitiveness of cities in Africa. Using this knowledge, African states can collaborate in order to leverage their resources and help to minimize costs when it comes to seeking out investment options for infrastructure development.

Keywords:

Acknowledgements

Special gratitude goes to Prof. Dr. Ronald Wall for your inspiration to explore the possibilities of this topic and the useful technical support towards conducting substantive scientific research. The exploration of the analysis methods in this research would not have been successful without the unsurmountable expertise of Drs. Bardia Mashoodi. I am really grateful for your guidance. I also appreciate my second reader for your substantive comments and input towards helping me improve this piece of work. Much appreciation goes to the Urban Competitiveness and Resilience team for the knowledge instilled in principles and theories in Economic geography, Statistics, Network Theories, Spatial analysis and Urban competitiveness. I have gained considerable insight and understanding in these spectrums.

I am thankful to the entire IHS community (teachers and staff) for a beautiful year. It has been a busy tough year but with your constant support and best management practices, it has come to a successful end. I am glad to have met such a diverse class of 114 participants from 41 nationalities! UMD14 the greatest, thank you for bringing the world to Rotterdam. I will forever miss the moments we spent together.

Special thanks to my friends Hayat, Maureen, Monica and Jacky for your motivation and support during the entire specialization and thesis-writing period.

This research has presented numerous opportunities for further research. It currently has explored centrality measures for the complete African continent. Meaningful comparisons could be made for the different economic zones, as this would be very useful to know which are the potential gateways that could bridge physical connectivity. This could help to enhance regional economic integration and healthy competition alike amongst the regional economic blocs. This kind of work could also be replicated at a smaller scale, within cities at a localized level, which could give insight on which streets are best suited for economic activities and where to bridge further connections.
Dedication:

To you: Theo, my beloved son.
For you have driven me to explore beyond my limits. You are deeply cherished by mama!
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>IHS</td>
<td>Institute for Housing and Urban Development</td>
</tr>
<tr>
<td>TAH-N</td>
<td>Trans-African Highway Network</td>
</tr>
<tr>
<td>FDI</td>
<td>Foreign Direct Investment</td>
</tr>
<tr>
<td>SS</td>
<td>Space Syntax</td>
</tr>
<tr>
<td>AFDB</td>
<td>African Development Bank</td>
</tr>
<tr>
<td>AU</td>
<td>African Union</td>
</tr>
<tr>
<td>WIR</td>
<td>World Investments Report</td>
</tr>
<tr>
<td>GCR</td>
<td>Global Competitiveness Report</td>
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<tr>
<td>GCI</td>
<td>Global Competitiveness Index</td>
</tr>
<tr>
<td>ACFTA</td>
<td>African Continental Free Trade Area</td>
</tr>
<tr>
<td>WDI</td>
<td>World Development Indicators</td>
</tr>
<tr>
<td>AIDI</td>
<td>Africa Infrastructure Development Index</td>
</tr>
<tr>
<td>PIDA</td>
<td>Program for Infrastructure Development in Africa</td>
</tr>
<tr>
<td>AICD</td>
<td>Africa Infrastructure Country Diagnostic</td>
</tr>
<tr>
<td>UNCTAD</td>
<td>United Nations Conference on Trade and Development</td>
</tr>
<tr>
<td>UNECA</td>
<td>United Nations Economic Commission for Africa</td>
</tr>
<tr>
<td>WEF</td>
<td>World Economic Forum</td>
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Chapter 1: Introduction

1.1 Introduction

This introductory chapter introduces the reader to the recent global trends on economic performance; with a specific focus on foreign direct investment (FDI) into Africa. It then highlights why Africa is a high potential area for attracting multinational firms and their subsequent investment. There are a number of factors that influence the locational decisions of foreign investors in the continent. Of particular interest to this study, is the influence of road network centralities. Therefore, an introduction is made on the Trans-African Network Highways masterplan and its purpose. This chapter serves to direct the reader into the specific problem that the research aims to address, as well as the aim, objective, significance, scope and the limitations of the study.

1.2 Background

Global trends, such as international trade and investment have over the past decades had a major impact on the economic performance of world regions. For instance, there has been slow economic growth in both the developed and developing world; following the 2007 global financial crisis, low and unstable commodity prices, political uncertainty and sporadic surges in global investment (World Bank, 2017, UNCTAD, 2017, Schwab and Sala-i-Martín, 2017). This has mostly affected developing countries. However, despite that, there are reasons to be optimistic. The World Bank shows that global economic conditions are constantly improving and this is expected to continue in the coming years. Global manufacturing over the past five years is reported to have achieved 6% growth rates annually (World Bank, 2017). Additionally, the Global Competitiveness report 2017, states that global GDP growth has recently increased to 3.5% (Schwab and Sala-i-Martín, 2017). The World Investment Report 2017 similarly reports that higher economic growth, improvement in trade and increase in corporate profits would lead to an increase in FDI to about $1.85 trillion in 2018 (UNCTAD, 2017). Financial markets, which have been established to have a significant relationship on FDI and economic growth (Otchere, Soumaré, et al., 2016) have also improved. This is evidenced by increasing international investments, increasing bonds and stable credit ratings in most firms in the capital markets (World Bank, 2017).

Importantly, the African continent also portrays growth. The African Competitiveness Report 2017 shows that between 2004 and 2014, the annual growth rate has been approximately 5%, which then stagnated to approximately 2.2% between 2015 and 2017. However, in 2018, growth is expected to rise to 4% and maintain this rate for the next few years (World Economic Forum, 2017). The World Investment Report (2017) also reports that although FDI decreased in 2016, with liberalization policies taking shape in Africa, FDI inflows are expected to take-off. Similarly, GDP, which has been established to be significant on FDI (Hansen and Rand, 2006, Anyanwu and Yaméogo, 2015); can be used to predict the potential of Africa in attracting foreign investments in future. The following image shows the trends of GDP growth. The
emerging and developing economies show a rising trend from 2016 onwards, prospecting for increasing foreign investments as well.

Graph 1: Global trends in economic growth

Urbanization, which is one of the most transformative trends of the 21st century also, has an influence on investment trends. It has been predicted that by 2050, the world population will have doubled (UN, 2015). The UNHABITAT also envisions that by the same year, about 64.1% of the developing world, and 85.9% of advanced economies will be fully urbanized (UNHABITAT, 2014). Other institutions have made similar accounts. For instance, World Bank says that Africa’s urbanization is growing at 4% annual rate in the largest cities. It also states that currently, urban areas in Africa hold about 472 million people, a number which is expected to double in the next 25 years (World Bank, 2017).

As much as urbanization poses its challenges, it also offers opportunities. For instance, urban agglomerations of people and activities fosters increased socio-economic interactions and network formation (Jacobs, 1969, McGranahan and Satterthwaite, 2014). This allows for the transfer of knowledge and ideas. With Africa urbanizing at a high rate, this is considered a positive aspect to investors. The UNCTAD Business Survey 2017 indicates that about 50% of corporate executives interviewed, think that global urbanization will lead to an increase in FDI (UNCTAD, 2017).

The figure that follows shows the world population trends and projections. It is important to note that the urban population of low developed regions portrays a constant growth trend.
Why is Africa a potential area for investment?

There are two key milestones in Africa, which can play a substantial role in attracting foreign investments, increasing regional integration and boosting the economic performance of Africa. These are the Trans-African highway network (TAHN) and the African Continental Free Trade Area Agreement (ACFTA). In March 2018, the African Union states signed the AFCTA. Liberalization policies and trade openness reduce the associated costs of doing business thereby attracting investments (Richaud, Sekkat, et al., 1999, Shepherd, 2016). Africa has a population of approximately 1.2 billion and total GDP estimated at US$ 2 trillion, which, UNCTAD asserts is a robust market that could positively transform Africa’s economy. By removing trade-barriers such as intra-African tariffs could result in US$ 3 billion gains (UNCTAD, 2017). The implementation of AFCTA and a complete TAH network will have a significant role in increasing regional integration within Africa, which is a key priority for the African Union.

The Trans-African Highway Network (TAH-N):

This is a master plan, envisioned and developed in 1969. Three organizations i.e. the African Development Bank (AfDB), the African Union (AU), and the United Nations Economic Commission for Africa (UNECA), have collaborated on this continent-wide project. The main idea behind this grand plan has been to connect all the African capital cities with a goal of facilitating the development of commerce, trade and tourism as well as fostering unity and peace.
among the people (African Development Bank, 2003). By linking key points of production and consumption,
this would open up inaccessible areas, improve access to basic human services and improve the economic performance of the continent (African Development Bank, 2003).

The following map shows the planned highway connections.

**Figure 1: Map of the Trans-Africa Highway Network**

![Trans-African Highways Map](https://commons.wikimedia.org/wiki/File:Map_of_Trans-African_Highways.PNG)

*Source: https://commons.wikimedia.org/wiki/File:Map_of_Trans-African_Highways.PNG*

Sadly, half a century later, there are still missing sections in this plan. Clacherty (2017) says that although it was highly full of promise, nothing much materialized with the TAH. He states, “I should point out at the outset that the Trans-African Highway (TAH) is not primarily, if at all, a
The influence of road network centrality on FDI attraction in Africa

road network. Although there are roads and many kilometres of highway that correspond to the routes marked out in the TAH master plan, many of them were built independently of the masterplan and have had a fluid, ambiguous relationship with the masterplan over time” (Clacherty, 2017).

Another aspect of concern is that there is inconsistency in the network and lack of standardization in the quality, size and capacity of these highways. Clacherty (2017) attributes this to the fact that the African states at the time gave priority to developing their own internal roads. Additionally, many of the highway authorities, which had been set up to oversee the implementation of the project never materialized (Clacherty, 2017). Henceforth, the absence of political will and an institutional framework played a major role in the failure of TAH master plan.

Benchmarking Infrastructure Development in Africa:

The African Union visualizes the roadmap for Africa’s development in the Agenda 2063. One of the aspirations of Agenda 2063 is to achieve integration within the continent. Under this, one goal enlisted is infrastructural development (African Union, 2014). Another aspiration is achieving prosperity and inclusive growth for sustainable development, which incorporates having modernized infrastructure. Additionally, transport development has long been appreciated as a means to achieve unity and freedom amongst African nations (African Development Bank, 2003).

A lack of physical and virtual infrastructure results in disjointed African cities with minimal interactions between people, which then hinders the growth of economic activities (Lall, Henderson, et al., 2017). In 2006, The Africa Infrastructure Country Diagnostic (AICD) estimated that addressing the infrastructure backlog would require $68–$93 billion annually over the next three decades (AICD, 2006). Africa’s infrastructure (particularly roads, telephone mainlines and power) is the slowest developing amongst developing countries (Bond, 2016).

Table 1: Road network density comparisons

<table>
<thead>
<tr>
<th>Africa</th>
<th>Low-Income Countries</th>
<th>Middle-income Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>152 km/km2</td>
<td>211 km/km2</td>
<td>757 km/km2</td>
</tr>
</tbody>
</table>

Source: Author, based on Infrastructure Consortium for Africa data (2015)

Despite road transport being the most frequently used mode of transport in Sub-Saharan Africa; estimated at 75% movement of passengers and freight, over 50% of the roads are in deplorable conditions (Beuran, Gachassin, et al., 2015). This negatively affects economic progress and Africa’s competitiveness (Bond, 2016, World Bank, 2017, Lall, et al., 2017). Clacherty (2017) notes that the role of the TAH in achieving greater connectivity has been underestimated, thus negatively hindering mobility.

Bond (2016) says that transport costs in Africa are twice high the cost in other developing countries. Additionally, the cost of trading in land-locked countries is 50 times higher than coastal countries in Africa and trade volumes are also 60% lower in the 16 land-locked countries.
(ICA, 2015). To illustrate the burden and impact that infrastructure deficit in Africa has on its competitiveness, the figure below shows the cost of importing a 20ft container.
Table 2: Comparison of Cost and Time implications for Importation

<table>
<thead>
<tr>
<th></th>
<th>Sub-Saharan Africa</th>
<th>Singapore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Cost</td>
<td>US $ 2,793</td>
<td>US $440</td>
</tr>
<tr>
<td>Average Time</td>
<td>38 Days</td>
<td>4 Days</td>
</tr>
</tbody>
</table>

Source: Author, based on Infrastructure Consortium for Africa data (2015)

Akpan (2014) uses a gravity model to estimate the impact of an improvement of the Lagos-Dakar road on trade in the ECOWAS region. He found that increasing the average road quality from 20.38 points to 100 points had the potential of increasing trade flows by 4.79%.

Wall et al. (2018) consider the utility of road network in the African West African states, specifically the Lagos-Abidjan corridor and its effect on FDI attraction. Interesting findings come from this study. They establish that high physical connectivity enhances the potential of attracting foreign investments. They also find that the local integration of road network at country level is positively significant for FDI attraction. However, for the global integration, the relationship was negatively significant with FDI. This means that majority of the West African countries are not physically connected to other cities in the world, so this hinders foreign investments. The conclusion held is that a well-connected and integrated road network increases mobility, access to markets, and resources. There are also improved linkages between points of production and consumption and this reduces the burden of transaction costs. It is from this point that we undertake this research to fully understand the potential of the complete African road network with the Trans African highways. We hypothesize that the utility of the road network has an impact on the potential of different cities in attracting foreign investments. Other existing roads stand to benefit by connecting to the TAH highways and/or being in close proximity to the TAH highways. This is measured through centrality measures like betweenness, reach, attraction distance, attraction reach and straightness, which shall be discussed later in detail. For instance, Johannesburg may have high connectivity as it is directly connected to other cities in Africa but have a low score on betweenness since it is further south and therefore not a common link between other city-connections. This has an impact on its choice amongst investors.

1.3 Problem Statement:

African cities develop in isolation, this to mean they are disjointed and fragmented and do not have sufficient infrastructural systems to connect them (Lall, et al., 2017). As a result, investors, firms and human labour incur huge transportation costs, which reduces the return on investments and for workers; they end up suppressing their disposable income. An efficient road transport system is a positive catalyst for the economic growth of a place through opening up new untapped markets, easing the movement of goods and services and increasing the mobility of people (Mukherjee et al. 2013). However, infrastructure development in Africa is currently very low as compared to the developed economies. This is the reason why investors would prefer ICT, digital and computer-electronics industries in developed economies and not in developing economies such as Africa (UNCTAD, 2017). Weak transport infrastructure development negatively affects the economic competitiveness of the continent. When comparing Africa with the other developing continents, it is reported that African cities are 20% more fragmented or disjointed than Asia and Latin American cities (Lall, et al., 2017).
Africa is not very integrated into the global economic network of investments. Only 5% of global investments are accounted for Africa against other parts of the world (World Economic Forum, 2017). Wall (2018) identifies factors contributing to these statistics. He argues that there is weak continental integration, low intra and inter-regional trade within Africa, inadequate skilled labour, less developed institutions, weak governance and low productivity levels (Wall and et al., 2018).

Key to attracting FDI inflows is continental integration; which can be achieved in one way through infrastructure connectivity. Golit et al. (2014) elaborate on models which have been applied in Africa to achieve regional integration. The most common approach that has always been used is intra-regional trade and import-substitution incentives. However, they state that this has not resulted in so much success. Other alternative models are physical and human capital accumulation, improvement of macro-economic conditions, reduction of business transaction costs and improvement of infrastructure. In their empirical study, they argue that paradigm shifts should be made by moving away from the traditional models of trade agreements and focus on capital accumulation and infrastructure development in order to achieve regional integration.

Most of the studies conducted on transport infrastructure look at issues of capacity, quantity and quality. Very few look at the utility of the transport network (Gutiérrez, Condeco-Melhorado, et al., 2010) and therefore the full potential/endowment of the system is not fully captured and understood. Understanding the utility of the African road network is necessary in order to inform investment decisions on where to best expand infrastructure and where to first prioritize in terms of financial investment.

- What is the full potential of the complete TAH network with the current road network?
- Can the utility of the road transport network be studied through analysing the network centralities; reach, betweenness, straightness, attraction distance and attraction reach?
- What is the influence of the centrality measures of different cities on attracting foreign investments?

The knowledge on the utility capacity of the TAH network is missing yet this is very important to African states. One of the challenges that has faced its development over the decades is due to a lack of commitment by the AU member states. This can be partly attributed to a lack of understanding of the full potential of transport continental integration and the impact it can have on the economic performance of the continent (Clacherty, 2017). It is expected that this study will shed some considerable light on the matter. The analysis of network centralities of road transport network and its impact on FDI locational choice at a continental level is also missing. The hierarchical effects of transport connectivity on FDI attraction and location for the whole of Africa needs to be established, which is the sole aim of this research.

1.4 Provisional Research Questions:

To what degree do statistically derived ‘network centrality’ measures of the African road network, affect the ability of major African cities to attract FDI, while controlling for other explanatory factors, i.e. the Global Competitiveness Index, Population Size, Trade openness and GDP?
Sub-questions are:
I. How do the network centrality measures i.e. reach, betweenness, straightness, attraction reach and distance help to understand the potential of the African highway system?

II. To what degree do these centrality measures of networks (a) the current African road network, (b) the Trans African Highways (c) the theoretically corrected network; influence the attraction of total FDI to major cities?

III. Based on network analysis techniques, which are the essential weak points in the network that can be developed in future to enhance greater connectivity in Africa?

IV. To what extent do the network centrality measures influence attraction of sectoral FDI into the Manufacturing, Service, Hi-Tech and Resource sectors?

1.5 Research Aim and Objectives:

The main aim of this research is to establish the impact of the network centrality of the current road transport network in Africa on the attraction and locational choice of FDI. This will help to explain the pattern of foreign investments in the past and to predict future trends in investment. With the analysis of the Trans-African Highway network with the major roads, this research also aims to identify the possible locations that have great potential for FDI attraction should they be physically linked.

In simple elaboration, first, the network centralities of the road network will be statistically derived and thereafter, the impact of these measures on economic activity will be analysed by comparing foreign investments across the continent.

The above-mentioned aim will be actualized through the following specific objectives:

I. To establish the impact of the current road network centrality on FDI attraction into Africa.

II. To analyse the impact of road network centrality on FDI attraction with the Trans-African highway network included.

III. To predict future potential areas for foreign investments through connecting weak physical connections.

1.6 Significance of the Study:

Infrastructure availability is a factor that facilitates the growth of FDI. However, how connected are regions in Africa? This research serves to add relevant scientific knowledge to the study of determinants of foreign investments by quantifying the level of road infrastructure utility through network centrality measures. The study of the utility of infrastructural networks is limited yet key in influencing locational decisions of both foreign and domestic investments.

The research intends to establish existing weak links and possible future road connections within Africa through which potential areas for investment can be realized. Prior to making an investment location decision, multinational corporations, extensively consider certain factors (Burger and Meijers, 2012). Therefore, such information will help to benchmark Africa at the global market as investors can clearly benefit from reliable information on return on their investments should they invest in certain locations in the continent.

The findings of this research can also inform policymakers and governments on where to prioritize road infrastructure projects. This is important as it helps to increase regional integration.
and ensure an equitable distribution of foreign investments across the continent. The knowledge of the
potential of a well-connected Africa can also influence the financing approaches of infrastructure projects, which is a great challenge in the continent. One can expect that African governments can collaborate on funding these projects if they have valid prospects on how they will benefit from such connections.

1.7 Scope and Limitations:

Infrastructure encompasses energy, water, electricity, internet connection and transport however, this research only analyses road infrastructure. This leaves out other transport modes such as rail, air, maritime and inland waterways. The influence of these modes on trade and investment flows cannot be underestimated. It is therefore important that future research look into the connectivity of other modes of transportation in order to fully depict Africa’s potential.

The research narrows down to focus on the level of utility of the road network and not capacity, quantity nor quality of infrastructure, which has been extensively studied in preceding studies (A. J. Khadaroo and Seetanah, 2007, Banno and Redondi, 2014, Akpan, 2014, Kodongo and Ojah, 2016). The geographical extent of this research is Africa. Investment patterns are analysed for an average of the past 10 years (2006-2016) and shall include:

i) Inward FDI value of investments from out of the continent.

ii) The variation of sectoral FDI in the continent: Manufacturing, Resources, Hi-tech and Services sectors.

An additional limitation of this study is the possibility of endogeneity between transport development and FDI investments. There could be reverse causality between these two aspects and this is something that is accounted for in this analysis. It is important to also mention that some observable/non-observable characteristics of the units of study could to some extent influence the correlation between the variables under study. For instance due to past colonial and historical influences, some cities receive potentially high FDI and their infrastructure is also well developed. Take for example, Cape Town and other South Africa cities. Historically, white settlers have stayed in South Africa for longer than other African states and it could be argued that for this reason, hypothetically, the country has better functional structures. Politically, some African cities house international organizations’ offices and this, to some extent, could influence infrastructure development and functionality of systems, thereby attracting foreign investments. This could potentially be assumed as causality between the aspects under study, while in essence, these characteristics have already influenced a high observance of the aspects. The influence of colony countries over their territories well after the countries’ independence could have an influence over their relations/policies regards doing business.

While finding comprehensive data on these characteristics was a challenge, it is advised that future research account for these aspects.
Chapter 2: Literature Review / Theory

2.1 Introduction:
This chapter reviews the state of the art of different theories featured in this study. It systematically reviews the importance of foreign investments in a location, what influences the locational decisions of multinational corporations in host countries and then discusses the role of transport infrastructure in attracting FDI into Africa. The basis of this research is formed on an understanding that the utility of a network has an impact on its economic function. In this regard, the network centrality measures of road transport network are discussed and how this has an influence on shaping the economic function of a place. The chapter also shows the conceptual framework under which the research is based.

The following concepts shall be discussed:

- Foreign investments and its relevance to Africa’s economy
- Factors influencing attraction of FDI
- Competitiveness between cities in attracting foreign investments
- The role of transport infrastructure in making cities competitive and attractive in Africa
- The network characteristics of the road network and its role in ranking the attractiveness of cities for FDI location

2.2 State of the Art:

Importance of FDI:

Foreign Direct Investments are cross-border capital flows. There are three primary modes of FDI which have been identified in literature. Meyer and Estrin (2001) discuss about green-field FDI, brown-field FDI and acquisitions. Green-field FDI involves new start-ups where an investor sets up everything from the start and invests their resources such as financial capital, knowledge and skills, management and expertise. Acquisitions on the other hand, involve an investor purchasing an existing firm and acquiring its ownership rights of the market share. Brown-field investment is defined as “a foreign acquisition undertaken as part of the establishment of a local operation. From the outset, its resources and capabilities are primarily provided by the investor, replacing most resources and capabilities of the acquired firm (Meyer and Estrin, 2001).”

It has been established empirically that FDI positively influences the economic development of a place. Along with its main impact, the transfer of capital to a recipient country, there is a continuous cycle of other benefits transferable to the recipient economy. FDI can be very instrumental in driving Africa’s development agenda by providing source of capital for several initiatives such as infrastructure development (Anyanwu, 2006, Asiedu, 2006). Additionally, FDI creates more employment opportunities, economic growth and sustenance, leads to increased productivity, supplements domestic savings, fills tax revenue gaps (Quazi, 2007), stirs entrepreneurial competition and knowledge transfers as well as technology spillovers (Dupasquier and Osakwe, 2003, 2006, Anyanwu, 2006, Abor, Adjasi, et al., 2008, Wall and et al., 2018). Bruno et al. (2017) conduct a meta-analysis of studies aimed at establishing the
spillover effects of FDI on economic performance for EU countries. They compare between old
15 EU countries and new
members into the EU, and establish that FDI has positive indirect impacts on productivity for the whole EU while controlling for the differences in the methodological approaches of the different studies under analysis. Lehnert et al. (2013) also establish that in addition to technological improvement and economic growth, FDI results in human development. They empirically show that through foreign investments, governments receive additional funds and resources to finance health and education projects thereby improving the social welfare of their citizens. There is a strong case for positive returns of foreign investments, not just for the multi-national firms but also for the host countries where these firms are set up. De Mello (1999) asserts that FDI can bring two-fold impact. First, as new firms incorporate new technologies and inputs into the production process; this causes growth in the host country. Second, FDI enhances knowledge transfers through labour training, delivering new skills as well as new managerial practices and organizational methodologies.

FDI also plays a critical role in integrating countries into the global economy (Anyanwu, 2006, Wall and Knaap, 2011). The activities between multinational corporations and their subsidiaries in different locations are what define the integration of these countries into the global economy. Globalization has constantly shaped the economic performance of regions; so to say, that cities which are well connected to other parts of the world are more prosperous. However, Africa still lags behind in attracting foreign investments. The continent only attracts 5% of global foreign investments according to (UNCTAD, 2017).

Wall et al. (2018) have recently showed the economic geography of FDI based on the global investments of multinational corporations. This reveals how there is a disproportionate distribution of investments as seen in the map below.

Figure 2: Global FDI flows 2018

Source: Wall et al. (2018)
Clearly, this scenario shows how Africa is ‘left out’ of the global economy, despite having high investment potential based on earlier discussions in chapter 1. Neo-classical theory states that
where capital stock is low, there are high marginal returns thereby attracting a high inflow of private capital (Mlambo, 2005). In contrast, Africa does not follow this logic, thus, an underlying question is why such is the scenario? In order to explain this question, we review what different authors have found out to be important for attracting foreign investments.

**Key Determinants for attraction of FDI:**

The discussion of factors that attract foreign investments cannot ensue without an understanding of the geography of multi-national enterprises. Dunning (1977) elaborated this by introducing the Eclectic paradigm theory. It is a tripod model consisting of three forces that drive the performance and thriving of investments. These forces are labelled as O-L-I as briefly described. O-Ownership refers to advantages derived from a firm’s access to assets, which help to generate income for the firm or have maximal return on their investments. These advantages derived through the transfer of intangible assets of the parent firms. L-Location represents locational advantages that a firm seeks in a location beyond its national boundary and which play a role in achieving maximum productivity for the firm, could be cheap labour. I-Internalization refers to advantages achieved from the firm’s ability to coordinate assets and activities internally. From the eclectic paradigm, he further identifies four motives behind investments. These are the need for resources, market share, achieving maximum efficiency and seeking strategic asset/capabilities (J. Dunning, 1993).

In a comparison of the motives of multinational corporations to invest in Africa and Europe, Wall et al. (2018) shows that the five most important factors for both regions as in the following order:

1. growth potential of the domestic market,
2. proximity to the market,
3. availability of skilled labour,
4. regulations that govern the business climate and
5. infrastructure and logistics (Wall and et al., 2018).


Resources have been known to be a motivating factor for inward FDI to countries with natural resources, however a study by Ndikumana and Verick (2008) establishes that telecommunication infrastructure is critical for attracting FDI into countries with no natural resources more than...
those endowed with natural resources. This then emphasizes the need for countries to improve their infrastructure in light of declining stocks of resources.

In an analysis of FDI flows for eight Southern Africa countries, democracy has also been established to have a mediating effect between FDI and economic growth. Countries which have well established democratic institutions, are likely to benefit from positive spillovers on their economic growth than those countries with weak democracy (Malikane and Chitambara, 2017). A forthcoming implication of this study is the need for African countries to drive policy reforms in order to strengthen their institutions.

Okafor et al. (2017) also show that trade openness, infrastructure development and controlled corruption have a significant impact on FDI inflow into Africa, whereas inflation and increased rent on natural resources deters FDI. Because of this, it is important that African states strive to improve conditions and policies that encourage investments in non-resource dependent sectors. Rodríguez-Pose and Cols (2017) prove that governance has long-lasting positive effect on attraction of FDI, thus governments should strive to build stable less corrupt regimes in order to facilitate FDI attraction up to the long run.

Countries attempt to create conducive environments for investments by improving the above-mentioned conditions, in order to increase their competitiveness. Turok (2004) explains that institutionalized competition is very important as it results in reinforcing advantages. Competition compels governments to deliver on infrastructure and services, which opens up new places to development. Due to efficient services and infrastructure, operational costs become less and this attracts investments. Additionally, as the governments rejuvenate cultural identity and heritage preservation, their cities become attractive to visitors, tourists and investors (Turok, 2004). Wheeler and Mody (1992) also support this through their analysis on important factors considered by U.S firms when making locational decisions. When explaining why governments would choose to compete for attraction of investments in what they term “locational tournaments”, they say that once a country has gained its locational advantages, it gains its edge because these advantages are re-enforcing (Wheeler and Mody, 1992).

Infrastructure development as a determinant of FDI:

There is wide agreement in academic and policy work that infrastructure has significant impact on the economic performance of a place. Singh and Kathuria (2016) state, “Infrastructure helps in building productive capacity by bridging connectivity gaps, reducing distribution and trade costs, and facilitating the sharing of the benefits of growth with poorer groups and communities, among others.”

Several studies have also been conducted on the impact of transport infrastructure on FDI attraction. Wheeler and Mody (1992) established that infrastructure quality is a dominant significant factor considered by investors into developing economies in the electronic and manufacturing industries. Asiedu (2002) showed that apart from natural resources, infrastructure is a key determinant of FDI into Africa. In her research, she considered telecommunication for infrastructure. Additionally, weak infrastructure is seen to be strong a constraining factor to multinational corporations’ set-up in most regions (Asiedu, 2002, Asiedu, 2006, Singh and Kathuria, 2016) and in low-income countries (Obwona, 2001). Bellak et al. (2009) also state that infrastructure endowment has a positive effect on increasing FDI to a country, however, with a caveat, that policies of tax and infrastructure should be analysed hand in hand as they have
opposing effects on investment returns. For instance, they state in (2009) “…a country may not lose FDI in the case of a tax increase relative to competitor countries if the country compensates
for it with an above-average infrastructure endowment.” Agreeable to this, Wheeler and Mody (1992) say that investor firms actually consider infrastructure quality more important than tax incentives in a host country.

By considering road and railway infrastructure quality in India, Kaur et al. (2016) establish that infrastructural quality and human resource quality has an important role in attracting FDI. Wall et al. (2018) also highlight that when evaluating issues of proximity to the market, this should be dependent on infrastructure connectivity between cities and within the cities. Cities with well-connected infrastructure have a high potential for attracting FDI. Donaubauer et al. (2016) evaluate the impact of infrastructure on attractiveness of FDI into developing countries and establish that targeted development assistance on infrastructure development has a positive impact on FDI. Their infrastructure index variable includes three combined infrastructure types of transport, energy and financial flows.

Another study establishes that the locational decisions of the multinational firms and domestic firms are influenced by availability and proximity to airports. This is entirely associated with transport costs and flow of knowledge. Using a dataset of 25 countries in Africa over the year period 1985-2004, Khadaroo and Seetanah (2009) were able to prove that air transport has a role in increasing FDI into these countries. Using the dynamic panel data model which accounts for past years’ effects, they found that not only does transport infrastructure capital make the countries attractive in the short run but also in the long run (A. J. Khadaroo and Seetanah, 2007). They argue that the underlying factors that make transport infrastructure attract FDI is because a good transport network increases accessibility and reduces transportation costs for the MNEs and indigenous firms whose motives are to maximize profits. Agreeable to this, Erenberg (1993) had earlier argued that the private sector and multi-national enterprises dislike situations where they incur additional costs in their operations, like, for example having to build new roads where there is none existing. In such an instance, they would definitely choose locations, which guarantee maximum return on their investments.

In their research on the influence of air transport connectivity over FDI, Redondi and Banno (2014) wanted to establish whether the spatial network of global airline systems affects inward FDI into Italy. They found out that the introduction of new routes had significant positive effects on FDI due to reduced transport costs and increased knowledge flows. Based on their results, they are able to argue that since urban areas stand to benefit from the existence of multi-national firms, policy makers should aim at increasing air transport capacity.

Richaud et al. (1999) show that infrastructure indeed has a positive impact on the growth of an economy. The growth, here, is determined by trade openness, global and domestic investments. Road infrastructure is considered along with other variables. They establish that road infrastructure positively relates with a growth in exports and that 1% increase in roads per capita causes 0.7% rise in FDI. Additionally, they also prove that increasing infrastructure capacity has spatial growth spillovers. In the recent past, Shepherd (2016) conducts a research in which focused on the role of infrastructure development and trade facilitation initiatives on global value chains. He considers the textile and clothing industry and agriculture industry in 189 countries, 44 of which are in Africa. First, he established that Africa entirely relies on external demand for its exports, continental links are relatively weak. Additionally, he found that policies aimed at transport infrastructure development and trade facilitation initiatives are positively correlated with value chain connectivity. Lastly, regional integration is crucial because he established that
when these two sets of policies are implemented in other neighbouring countries, this has an impact on the
global value chain connectivity of a home country. This implies that the actions of neighbouring countries or in a particular region influences a country’s performance.

Additionally, Kodongo and Ojah (2016) found that infrastructure has a positive impact on economic development. They use the infrastructure index developed by The African Development Bank, which includes measures of capacity (bulk) and for some infrastructure types, quality indicators as well. The index is a combination of several variables of four infrastructure types, namely, Information and Communication Technology, water and sanitation, electricity and transport. The bulk indicators include road network per km and the quality indicators include, percentage of population accessing clean water or percentage of paved roads.

**Transport Network Analysis and Space Syntax:**

It is important to note that most of the studies that have evaluated transport infrastructure effects on FDI have only focused on issues of transport quality (type of road) and quantity dynamics (capacity level) and some have evaluated infrastructure in general, by means of an index including telecommunication, water, electricity, energy and transport. This study will focus on the impact of road network utility on FDI attraction. This shall be derived through Space Syntax analysis.

Hillier developed the space syntax theory to empirically show the spatial characteristics of cities and the effect this has on the function of the city. Based on graph theory, space syntax helps to model the interactions within a spatial network into a connection graph, through which it derives a value associated with each characteristic such as connection, accessibility, depth and integration (Hillier, 1997, Hanson and Hillier, 1987). In concurrent with that, Tsou et al. (2015) say that the spatial layout of transport infrastructure network influences the spatial development of a region and determines the different spatial activities at different geographical scales, say the city level. Batty (2008) also proved that cities are a product of millions of individual decisions on many spatial scales over different time intervals thus affecting the form and function of the city with respect to how it is structured and evolves. In order to fully express and capture the relationship of the form and function of space (architecture and behaviour), Hillier and Hanson (1987) state that territory theory is the most intelligible way of capturing the characteristics of space by use of graphic and spatial techniques, expressed in a mathematical value.

A set of fundamental principles are laid out:

i. How space is organized will determine a place’s form and function

ii. Movement and spatial configuration of a network are synchronous, and through these two elements, socio-economic processes will shape the form and function of a city

iii. Form and function are dependent on each other

iv. The structure of the spatial network has a powerful influence over movement patterns and consequently the urban pattern and the location of different land uses (Hillier, 1997, Hanson and Hillier, 1987).

The application of space syntax measures can be applied to the centrality of transport networks. Linbo et al (2017) use space syntax to analyse the factors influencing different accessibility measures of the metro system of Xi’an in China. They were able to explain certain passenger behaviours and preferences, and consequently, identifying which other stations are easy to access from the city centre. This helps to inform on the nature of designs for future metro-line developments. Tsou et al. (2015) identify the benefits of space syntax. They claim that it is
possible to analyse network structure characteristics at different geographical scales through space syntax.
Secondly, one can easily identify the accessibility of transport network without having to determine the trip origins and destinations and thirdly, through different indices, different scales of connectivity can be identified, namely, connectivity, control, local integration and global integration, which are correlated with the density of use of a spatial system (Hillier, 1997).

To demonstrate the impact of accessibility on a country’s economic activity, Lall et al. (2008) used the potential accessibility index to test whether market access has an impact on the increase of private investment in a city. The empirical results showed that a 10% increase in market access of a city would result in a 5.7% increase in private investment in the manufacturing sector. In a similar exercise, but testing market access impact on labour productivity, Yoshida and Deichmann (2009) established that a 10% increase in market access within Mexico causes a 6% rise in labour productivity. In another study, Tsou et al. (2015) analyse the effects of different indicators of accessibility at the local level and regional level using the highway network in Taiwan. They established that there is a high correlation between accessibility and local development patterns. Gutiérrez et al. (2011) also demonstrate that accessibility can demonstrate how mobility, socio-cultural dynamics, economic development and environmental impact are influenced and inter-related. They do this by analysing the spatial spillovers of the Spanish transport infrastructure plan.

Yoshida and Deichmann (2009) state that the accessibility index can be employed as a monitoring and evaluation tool to establish the outcomes of public infrastructure investments, for instance, in improvement of road networks or increase of capacity.

In their study of the transport system network of Europe, Gutierrez and Urbano (1996) sought to measure which regions will gain from an increase in accessibility after the full completion of the network in 2002. They based this on these indicators- accessibility to the network and accessibility to the main activity centres along the network. Through GIS analysis, they demonstrated that the percentage coverage of land in proximity to the proposed road network increased from 70% in 1992 to 85% in 2002. They also showed that peripheral regions would gain a substantial increase in GDP since they would now have increased accessibility to market centres (Gutiérrez and Urbano, 1996).

By use of the accessibility index of the transport infrastructure plan of Spain, using GIS, Gutierrez et al. (2010) were able to calculate the potential economic benefits of new regions based on the spillover effects (as % of direct investments). Consequently, in another project by the European Union, the Trans-European Network Transport (TEN-T), they went further to establish which regions would achieve highest efficiency based on accessibility score. They were able to statistically give regions a score, what they refer to as EVA (European Value Added), therefore establishing the level of territorial cohesion regions would achieve consequent to the development of the TEN-T network (Gutiérrez, et al., 2011).

**Feasibility of Large Geographical Scale Analysis:**

Is this scale of research feasible at a continental level? Serra and Pinho (2013) address this subject in their analysis of a metropolitan region, where they introduce a method of tuning space-syntax to perform this kind of analysis. They describe the challenges associated with analysing large spatial systems, and in this case, the Continental Highway Network comes into context. The first analytical constraint identified is obviously the large territorial extent (Serra and Pinho, 2013). Although this is a constraint, credible research of such spatial systems should be rigorous
and any conclusive results should be a representation of the entire spatial extent. The second analytical constraint is the fact that large spatial systems are polycentric in form; therefore, they are incorporated of several urban centres (Serra and Pinho, 2013).

To achieve rigorous, reliable analysis of large spatial systems, the authors propose a set of four conditions subject to which, analysis is feasible.

i. The spatial analysis models should have a resolution capable of representing analysis at both the larger territorial extent and at the micro-level.

ii. The model should be able to capture and present the hierarchical interactions between different spatial scales (regional, local) within the larger system.

iii. The model should be able to present the situation as it is without the influence of theories on spatial organization and it should be replicable in all geographical contexts.

iv. The model should address all the structural aspects of a spatial system so that the analysis may prove its relevance (Serra and Pinho, 2013).

To demonstrate that large-scale investments have return on investments, different models can be used. Kiel et al. (2014) explain, “Transport models are able to capture the direct effects such as changes in travel costs or changes in volume of passengers and goods. Economic models are used to incorporate the indirect effects of infrastructure investments, such as employment or economic growth.” This research intends to capture the potential of the road network in Africa by using spatial-econometric analysis as will be elaborated further in the following chapter.

**In summary:**

Much of the literature reviewed up to this point strongly suggest that both FDI and infrastructure development improves the economic growth of a place through capital accumulation, knowledge transfers, technological improvement, increased productivity, expansion of markets, lowered production and transaction costs and improved access amongst other possibilities. Additionally, transport infrastructure is a key determinant in attracting FDI to a region through increasing access to markets and easing the cost and time for business transactions. Importantly FDI plays an important role in integrating a country into the global economy. Transport infrastructure, on the other hand, is instrumental in increasing regional integration of Africa amongst other improvements in intra-regional trade and economic development. Empirical studies support that regional integration favours FDI attraction, however this is dependent on factors such as specific trade and investment policies within a region and geographical position of smaller-sized countries in relation to larger-sized countries. With this in mind, we hypothesize that through improvement of transport connectivity, regional integration will be increased within Africa and consequently increase inward FDI and within the continent. To test this hypothesis, we shall evaluate transport network through centrality measures in order to fully understand the impact of road utility on FDI attraction.
2.3 Revised Conceptual Framework

Figure 3: Visualization of the Conceptual Framework

The Conceptual Framework Explained

The road network utility influences the economic function of a place. This is quantified through the network centralities measures. Economic function can be described through trade activities, local investments, robust, functional capital markets and foreign investments amongst other activities. However, in this context, foreign direct investments is used as a proxy for economic function. Cities or countries compete in order to attract these foreign investments. They therefore try to improve local conditions in what is termed here as competitiveness factors which include quality of institutions, infrastructure quality, macro-economic environment, labour and financial markets, education, training, technology and innovation amongst other factors (Schwab and Sala-i-Martín, 2017, World Economic Forum, 2017). Therefore, we see the competitive factors as having an influence over the main variables under study. The current major roads network and the TAH-N forms the basis of the spatial analysis and this happens within the geographical scope of the African continent. The hypothesis which shall be tested is the presence of reverse causality between the dependent and independent variables hence the reason for a double-sided arrow.

Self-selection is also a possible limitation with regards to the relationship of the two aspects under study. This could be as a result of observable/non-observable characteristics as discussed in the section under Scope and Limitations. Due to this, an Instrumental variable shall be introduced to help account for possible endogeneity.
Chapter 3: Research Design and Methods

3.1 Introduction:
The purpose of this chapter is to describe extensively the approach undertaken to conduct the research, the methods which are applied for gathering data and analysing the data and the measures undertaken to ensure validity and reliability of the process. It will also expound on the meaning of different concepts as applied in this research and the manner in which these concepts are operationalized into measurable and observable variables for the purpose of drawing meaningful interpretation. In summary, this chapter should enable the reader to understand how the research has been conducted, in essence; the research design.

3.2 Revised Research Questions
To what degree do statistically derived ‘network centrality’, measures, of the African road network, affect the ability of major African cities to attract FDI, while controlling for other explanatory factors, i.e. the Global Competitiveness Index, Population Size, Trade openness and GDP?

Sub-questions are:

I. How do the network centrality measures i.e. reach, betweenness, straightness, attraction reach and distance help to understand the potential of the African highway system?

II. To what degree do these centrality measures of networks (a) the current African road network, (b) the Trans African Highways (c) the theoretically corrected network; influence the attraction of total FDI to major cities?

III. Based on network analysis techniques, which are the essential weak points in the network that can be developed in future to enhance greater connectivity in Africa?

IV. To what extent do the network centrality measures influence attraction of sectoral FDI into the Manufacturing, Service, Hi-Tech and Resource sectors?

3.3 Operationalization: Concepts, Variables and Indicators
When research evolves from the phase of theoretical understanding to empirical execution, it undergoes a process of operationalization, which is, converting the concepts under research into observable and measurable entities (Van Thiel, 2014). Under this sub-section, the concepts employed in this study are discussed below and how they will be measured.

Dependent Variable

Space syntax theory and global economic integration influence the concept of the economic function of a place. Foreign investments into African cities from outside the continent are used as a proxy for the economic function of cities. It has been reviewed in the past chapters that foreign investments positively influence the economy of a place. A sectoral comparison of foreign investments is also carried out because different sectors show variation in their preferences for location. These sectors are Manufacturing, Services, Hi-Tech and Resources FDI. Therefore, FDI value as a total and in different sectors are the Y-Variables. The scale of measurement is ratio because FDI value is a continuous figure with an absolute zero value.
Table 3: Dependent Variable

<table>
<thead>
<tr>
<th>Concept</th>
<th>Variable</th>
<th>Indicator (s)</th>
<th>Scale of Measurement</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic Function</td>
<td>FDI activity</td>
<td>Total FDI Value</td>
<td>Ratio Scale</td>
<td>FDI Markets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sectoral FDI Value Hi-tech, Manufacturing, Service, Resources</td>
<td>Ratio Scale</td>
<td>FDI Markets</td>
</tr>
</tbody>
</table>

Independent Variables

The explanatory variables of this research are based on the network centrality measures of the road network of Africa. Centrality measures are mathematical computations based on a spatial network with an aim of quantifying the relevance of each node (city location) in the graph (road network) with respect to other surrounding nodes (cities). These measures are Reach, Betweenness, Straightness, Attraction Reach and Attraction Distance. Reach, Betweenness, Straightness are derived using the Urban Network Analysis toolkit in ArcMap GIS whereas Attraction Centralities are derived using Place Syntax Toolkit in QGIS. Both of these toolkits generate the axial/segment map of the road network using the same principles, however they have different capabilities of measuring different aspects. The principle behind these measures is based on the understanding of space syntax theory, which holds that axial graphs can fully represent urban space networks and their consequent interactions. Through an intersection of a network of axial lines, an axial map is derived which visually presents the existing connections within a spatial space (Hanson and Hillier, 1987).

The network measures:

1. Attraction Distance:
This calculates the minimum distances from an origin (city) through the network to the closest destination, within a specified distance. This was calculated using two parameters, the straight line distance (10,000Km) and angular radius (360°). 10,000 Km is justified as a reasonable threshold that can fully cover the maximum possible extent between cities since Africa’s continental extent is around 8000Km by 6500Km. 360° was also chosen as it guarantees end-end coverage. Due to collinearity, results that are less significant are dropped. This means that, for some cities, more distances are calculated and for others fewer distances are calculated, because the radius is the delimiting factor of the number of destinations (other cities) whose distances can be calculated.
The formulae for the measure is as:
Equation 1: Attraction Distance

Attraction distance AD for a given origin \( o \) is calculated as:

\[
AD(o) = \min_{a \in A}(D(o, a))
\]

where

- \( A \) = the set of reachable attractions within given radius
- \( D(o, a) \) = shortest distance from origin \( o \) to attraction \( a \).

2. Attraction Reach:

This measure gives the sum of all attractions (cities) that can be reached from each origin (city) within a specified radius within the network. The radius defined are 10,000Km and 360 °. The algorithm for calculating this metric is similar to that of Attraction Distance but for this, every attraction reached, its score is added up to the origin city score.

Equation 2: Attraction Reach Centrality

Attraction reach AR for a given origin \( o \) is calculated as:

\[
AR(o) = \sum_{a \in A}(f(a)w(D(o, a)))
\]

where

- \( A \) = the set of reachable attractions within given radius
- \( f(a) \) = attraction value associated with attraction \( a \), or 1 if no attraction value is used
- \( D(o, a) \) = shortest distance from origin \( o \) to attraction \( a \)
- \( w(x) \) = attenuation function

3. Reach:

This metric is very similar to Attraction Reach derived through the PST tool; however, the difference is that this uses population weights. Thus, it measures the number of nodes reachable at the shortest path within different radii; 30Km, 100Km and \( n \)-radius. Weighting allows the metric to calculate how many of the attribute can be reached from each origin to other destinations. All different radii are measured, however, only those that display significance are included in the final models. The formulae below shows this measure.

Equation 3: Reach Centrality

\[
Reach^r[i] = \sum_{i \in G - (i) : d[i,j] \leq r} W[j]
\]

where \( d[i,j] \) is the shortest distance between nodes \( i \) and \( j \) in network \( G \) and \( W \) is the weight of the variable of interest.
4. **Betweenness:**
This measure of centrality calculates the number of times a node (city) lies within the shortest path distance between pairs of other cities within a specified radius of the road network. The radii measured are 30Km, 100Km and n-radius. If more than one short path is found, then they are given equal weights.

**Equation 4: Betweenness Centrality**

\[
Betweenness^r[i] = \sum_{j,k \in \mathcal{G} - \{i\}; d(j,k) \leq r} \frac{n_{jk}[i]}{n_{jk}} \cdot W[j]
\]

Where \( n_{jk} \) is the shortest paths between cities \( j \) and \( k \) in network \( G \), whereas \( n_{jk}[i] \) is a set of the paths which cross through city \( i \) and lie within radius \( r \). \( W[j] \) and \( i \) is the weight for population in destination \( j \).

5. **Straightness:**
This metric shows how closely the short distance connections between a city origin to other city destinations are similar to Euclidean distances, within the network \( G \) and within radii 30Km, 100Km and n-radius.

**Equation 5: Straightness Centrality**

\[
Straightness[i]^r = \sum_{j \in \mathcal{G} - \{i\}; d(i,j) \leq r} \frac{\delta[i,j]}{d[i,j]} \cdot W[j]
\]

Where \( \delta[i,j] \) the Euclidean distance between cities \( i \) and \( j \), \( d[i,j] \) is the shortest distance between the cities and \( W[j] \) is the weight of destination \( j \).

**Table 4: Independent Variables**

<table>
<thead>
<tr>
<th>Concept</th>
<th>Variable</th>
<th>Indicator (s)</th>
<th>Measurement</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Infrastructure</td>
<td>Network Centrality Measures</td>
<td>Reach</td>
<td>Ratio Scale</td>
<td>UNECA Road Network data (shape files)</td>
</tr>
<tr>
<td>is important for investment activity</td>
<td></td>
<td>(30Km, 100Km, nKm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and economic integration</td>
<td></td>
<td>Betweenness</td>
<td>Ratio Scale</td>
<td></td>
</tr>
<tr>
<td>Form influences</td>
<td></td>
<td>(30Km, 100Km, nKm)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Control Variables
These are indicators which have been identified theoretically as having an influence on major aspects under study. They are introduced into the statistical model in order to make sure that the reported results are valid and reliable and can be attributed in a strict sense to the correlation between the dependent and independent variables.

Table 5: Control Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Indicator (s)</th>
<th>Measurement Scale</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure Development Index</td>
<td>Transport Composite Index</td>
<td>Ratio</td>
<td>AIDI</td>
</tr>
<tr>
<td>Economic Performance</td>
<td>GDP</td>
<td>Ratio</td>
<td>WDI</td>
</tr>
<tr>
<td>Openness to trade</td>
<td>% Trade of GDP</td>
<td>Ratio</td>
<td>UNCTAD</td>
</tr>
<tr>
<td>Competitive Index (12 pillars)</td>
<td>GCI</td>
<td>Ratio</td>
<td>WEF</td>
</tr>
<tr>
<td>Labour Force</td>
<td>Population Size</td>
<td>Ratio</td>
<td>World Bank</td>
</tr>
</tbody>
</table>
thought to be correlated. Transport infrastructure has been theoretically established to be significant for foreign
investments, and to account for this, the Global Competitiveness Index is used which also
includes the quality of transport infrastructure. The fitness of the instrumental variable shall be
tested as will be seen in the following Analysis chapter.
With the operationalization elaborated, the linear equations employed in this analysis are as-

**Equation 6: Linear model of Total FDI**

\[
\text{Total FDI} = \alpha + \beta_1 \text{Centrality Measure} \times + \beta_2 \text{Labour Force} + \beta_3 \text{Competitiveness} + \beta_4 \text{Trade Openness} + \beta_5 \text{Economic Performance} + \varepsilon
\]

**Equation 7: Linear model of Sectoral FDI**

\[
\text{Sector FDI} = \alpha + \beta_1 \text{Centrality Measure} \times + \beta_2 \text{Labour Force} + \beta_3 \text{Competitiveness} + \beta_4 \text{Trade Openness} + \beta_5 \text{Economic Performance} + \varepsilon
\]

**3.4 Research Strategy and Methodology**

The approach of this study is through a desk research strategy. It uses spatial and statistical data
as accessed from secondary sources (FDI Markets, World Bank, WEF, UNCTAD, Geospatial
Shape files) for analysis. This strategy was preferred because of the large geographical scope
of this research, which is at a continental level. Availability of data is also a driving factor in using
this strategy (Van Thiel, 2014).

A number of models are analysed. The first one is an analysis of centrality measures for the
existing road network, the second one is with the TAH network of highways included and the
third model is based on an improved network with improved connectivity in weak links between
some cities. 374 cities are used for the whole road network comparison and for the Trans African
Highways, 141 cities which are selected within a 10Km radius. The research is then achieved
through a twin methodology, namely geographical-statistical model. On a geo-spatial platform
(ESRI ArcMap and QGIS, centrality measures of the road network centrality are derived using
the Urban Network Analysis Toolkit and Place Syntax Toolkit. The results are assigned to each
city in the network and then this dataset has been imported into Stata for Statistical Analysis. The
correlation of the network measures and foreign investments is then established.

**3.5 Sample Size and Selection**

The scope of the research is Africa as a continent and analysis is undertaken at city level. There
about 374 cities, whose information for most variables is available. These were selected from a
possible 521 cities, however, only those with population data available qualified for this analysis.
This is because population is used for weighting in the calculations of a number of the centrality
measures. For cities within a 10Km radius of the Trans African Highways, about 141 cities are
used to evaluate the potential of the Trans African Highways. For the theoretically corrected
network, approximately 50 cities are compared pre and after new connections are created, in
order to answer research sub-question III.

For the spatial data, road network was available for the whole continent, for the major highways
and roads. The network system was the basis for creating the axial/segment maps.
3.6 Data Collection Methods
Secondary data is gathered from existing databases such as FDI Markets, World Development Indicators, UNCTAD, UNECA and AfDB. The nature of data varied from spatial to statistical form. Data cleaning was done in order to select from the database data which is important for this research, for instance creating an average of the year 2006-2016.

Spatial data for the dependent variable, that is road network, was gathered through a secondary source in a spatially configurable format, which then was used to derive primary data, as the network centrality measures.

3.7 Data Analysis Methods

Descriptive Statistics:
Before the econometric analysis, it is necessary to have an overview of the available data on FDI and thereafter for the road network centrality measures. Descriptive statistics of measures of central tendency such as maximum, minimum, mean, median, standard deviation and variance are first established.

Pre-Analysis Assumption tests:
Tests for Reliability of Variables—Several tests need to be conducted on the variables to check their reliability to be used further in econometric analysis and to aid in selection of the suitable econometric model. These include tests for linearity, check for outliers, multi-collinearity, homoscedasticity and normality of the distribution.

Spatial Analysis:
Road network data is developed in GIS and QGIS as an axial/convex analysis graph. Mathematical computations of the network help to derive measures of road network reach, betweenness, straightness and attraction distance/reach. The formulas discussed under Independent Variables section have been computed. These will be the basis for quantifying the level of utility of the network. This will then be exported as a (.csv) file, which will be joined with FDI statistical data for available cities. Then, the next stage is the inferential analysis which is carried out in Stata.

Inferential Analysis: The 2SLS Model
Inferential Analysis is carried out in order to establish the relationship between the variables applied in the model. The purpose is to test the effect of the independent variables (road network centralities) on the dependent variable (FDI attraction) while controlling for other important variables.

As depicted under the Conceptual framework, causality between the dependent and independent variables is not definite, that is, FDI attraction could also have an impact on the utility of the road network system. To test for endogeneity, the 2SLS econometric model is used. Wooldridge (2015) elaborates on this model as discussed below.

The model requires identification of an instrumental variable. The instrumental variable is an external variable related to the independent variable and has an impact on the dependent variable.
The influence of road network centrality on FDI attraction in Africa

but only through the X-variable. Additionally, it should not be related with the error term of our regression equation.

Therefore, these assumptions should be met:

a. Z (Instrumental Variable) is uncorrelated with ε (error term)
   \[ \text{Cov}(z, u) = 0; \]

b. Z is correlated with X (independent variable)
   \[ \text{Cov}(z, x) \neq 0. \]

After obtaining the instrumental variables, the 2SLS model occurs in two stages:

1. First, the simple linear regression with the instrumental variable is run in order to obtain the fitted values of the main endogenous variable;

   \[ X = a_0 + a_1 Z + a_2 V + a_3 W + u \]

2. Second is to replace the fitted values where the initial x variables where

   \[ Y = b_0 + b_1 \hat{X} + b_2 V + b_3 W + \varepsilon \]

Control variables are included in both stages of analysis

Therefore, the final equation for the analysis is;

\[ Y = b_0 + b_1 \hat{X} + b_2 Z + b_3 W + \varepsilon \]

Where \( Y \) = dependent variable
\( B = \) intercept terms
\( \hat{X} = \) independent variables with fitted values
\( Z = \) instrumental variable
\( V = \) other x variable (s)
\( W = \) control variable (s)
\( \varepsilon = \) error terms

The Wu-Haussmann Test has been used to test for endogeneity.

The test for endogeneity is important, as it not only accounts for instantaneous bias; but also accounts for possible measurement errors and omitted variables.
### Table 6: Summary of Theoretical underpinnings for the variables

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Research Question and Methodology</th>
<th>Explanatory Variables</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall et al. (2018)</td>
<td>Hard connectivity of Lagos-Abidjan corridor and impact on FDI attraction in West African countries</td>
<td>Road network centralities (connectivity, integration, choice)</td>
<td>High local integration has a positive significance on FDI attraction. Global integration is significant for FDI, however it was negative due to low integration of West African cities to other cities in Africa.</td>
</tr>
<tr>
<td>Dunning (1981,1988)</td>
<td>Determinants of FDI</td>
<td>Eclectic theory</td>
<td>Ownership advantages, Internationalization and location-specific advantages are the main motives for location of FDI.</td>
</tr>
<tr>
<td>Ben Shepherd (2017)</td>
<td>Infrastructure, Trade Facilitation and Network Connectivity</td>
<td>Trade flows, GDP Per Capita, Logistics Performance Index</td>
<td>-There is a link between infrastructural links and trade facilitation and network connectivity of global value chains.</td>
</tr>
<tr>
<td>World Economic Forum (2017)</td>
<td>Global Competitiveness</td>
<td>GCI Index</td>
<td>-All these factors have an influence on the competitiveness of a city, therefore its ability to foster economic vibrancy.</td>
</tr>
<tr>
<td>Khadaroo and Seetanah (2008)</td>
<td>Transport Infrastructure and FDI</td>
<td>Natural Resource Intensity, Market size, labour cost, human capital, political stability, GDP, infrastructure (level and quality)</td>
<td>-Transport and None-transport infrastructure is necessary to making countries attractive to foreign investors.</td>
</tr>
<tr>
<td>Ben Shepherd (2016), Richaud et al (1999)</td>
<td>Trade facilitation, Trade openness impact on investments</td>
<td>Trade volumes per GDP and other control variables</td>
<td>Liberalization policies and reduction of taxes for trade have a positive influence in boosting trade and investment activities.</td>
</tr>
</tbody>
</table>

### 3.8 Reflection on Validity and Reliability

Desk research has been established to have quite a number of limitations. Van Theil (2014) identifies that there could exist a mismatch between your desired variables of study and existing data. In this case, for instance, analysis is on a city level, and even though the main dependent and independent variables data is on city level, for some control variables, data is only available on a country level. Positively, this data can be statistically used to represent the cities. Another limitation is the lack of consistency in the methodology of computing secondary data over the years. However, the datasets employed in this research are from credible sources and have been previously used for many scientific researches, therefore they guarantee reliability. Additionally,
the methods of computation for the indicators have been verified to be standardized over the years.

In order to ensure internal validity, a number of assumption tests are carried out on the dataset. Such tests include linearity, outliers, multi-collinearity, heteroscedasticity, normality of distribution and check for omitted variables. Importantly, key control variables are introduced into the econometric models in order to ensure that the exhibited results are strictly related to the aspects under study and not due to other influences. The econometric model employed in this research is the IV/2SLS model, followed by the Wu-Haussmann test. As this is a linear model; the key assumption is that X is uncorrelated with the unobserved determinants of Y. This is the exogeneity assumption. When this assumption is violated, endogeneity is taken to be present. Wooldridge (2015) elaborates that this could be due to measurement errors (attenuation bias), instantaneous causation (simultaneity bias) and omitted variables (selection bias). This model approach is reliable for establishing whether there is reverse causality between the dependent and independent variables and the other mentioned causes of endogeneity (Wooldridge, 2015).

Self-selection is a potential limitation to the study. This could occur in the instance where observable/non-observable characteristics such as the history of a place could account for high sources of FDI received and well-developed infrastructure as elaborated in the section under scope and limitations.
Chapter 4: Research Findings

4.1 Introduction:
A section that describes the findings and results of the spatial and statistical analysis. Significant outcomes of the correlation between the dependent (foreign investments) and independent (centrality measures) are reported. There are different sub-sections on the descriptive and inferential analyses, and based on different networks, namely: the current road network, the Trans African Highways network and the improved connectivity network. Different sectors of FDI are also analysed and discussed. The output is displayed by form of maps, charts, tables, graphs and images. This chapter forms the basis for the following chapter on conclusions and recommendations.

4.2 Descriptive Analysis
Theory shows that spatial form influences function. Road network centrality measures span out of the spatial form of a place. We hypothesize that these centralities have an impact over the economic function of different cities in Africa. The economic function is established through FDI values in the cities.

FDI has certain factors that influence its location. Infrastructure development has been empirically established as to be one of these factors. In this study, we test whether centrality measures exhibit an influence over FDI attraction in a place. We used a dataset of the time period 2006-2016. An average of the time period is established for every variable and these are the summary statistics. Total FDI was the main dependent variable; however, sectoral FDI is also used for comparison purposes and to establish variation. The distribution of Total FDI as seen in Graph 2 is skewed to the right, showing that there is a high concentration of low FDI value in many observations. In order to maintain a reasonable number of observations, viewing them as outliers would compromise the dataset. Thus, it is Log transformed to give a normal distribution. The results are as seen in Graph 4.

Graph 3: Histogram of Total FDI
Graph 4: Histogram of Log Total FDI

The initial dataset had 521 cities from 54 countries. Due to missing variables in other control variables and after computation of the centrality measures, the eventual dataset that has been used for analysis has 374 cities as observations from 38 countries.
Table 7: Description of the main dependent variable

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observations</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log Total FDI</td>
<td>374</td>
<td>4.508359</td>
<td>1.973934</td>
<td>0</td>
<td>9.367905</td>
</tr>
</tbody>
</table>


**Distribution of Sectoral FDI: Resources, Service, Hi-Tech and Manufacturing FDI**

The chart below shows the FDI value per sector. It appears that majority of foreign investments into Africa are set up for manufacturing activities (46000 million US$) followed by services (24000 million US$). Contrary to popular belief that the main motivation of foreign investments into Africa is the drive for resources, the data shows that resources FDI is second to last. Hi-Tech FDI is probably scoring low due to the slow technological development within the continent. Manufacturing FDI leads in total value invested into Africa at 58.97%, Services FDI come closer at 30.77%. Resources FDI is third at 8.97% whereas Hi-Tech FDI staggers behind at 3.08%.

**Graph 5: Distribution of foreign investments into Africa by sector**

The maps that follow show the spatial distribution of the different sectoral FDI across different cities within the continent. Please note that all the maps used in this section are the generated by the author using data from the UNECA and FDI Markets.

**Map 1a, b, c and d: Distribution of Sectoral FDI across the continent**

![Distribution of Resources FDI](image1)

![Distribution of Hi-Tech FDI](image2)

The size of nodes depicts FDI value. Hi-Tech FDI is the least received investment as shown by the size of the nodes. There is a high concentration of lower sized nodes as compared by bigger sized nodes. Despite the values of Hi-Tech FDI being lower than Resources FDI in general for the continent, it seems to be higher for the Trans Highways cities, those that lie on the highways or are within 10Km distance from the highways. It is clearly seen that larger nodes in Hi-Tech map are majorly at the highways and their intersections. Services and Manufacturing sectors attract more foreign investments into the TAH cities than the Resources and Hi-Tech sectors. For the Services sector, the difference in the values of investment between the highest and lowest values is not that high. The investments also seem to be evenly distributed and no specific preference to the Trans Highways. On the other hand, Manufacturing FDI, which is the highest received investments in the continent consequently, has higher value nodes. The maps that follow show the distribution.
The road network distribution and the consequent segment map

The following map 2 shows the extensive road network and the nine Trans-African Highways. It is important to note that these highways are not completely connected and also lack a common standardization across the different countries they transverse; however for the purposes of this research, the complete planned routes have been used.

Map 3 is the output of an axial/segment map, which is the basis for computing centrality measures. The Place Syntax Toolkit was used to generate the road network graph. The basic principle behind the graph is that connections are based on the shortest straight-line path that connects different places. The input was the road centre-line polylines. The create segments tool finds all intersections and unlink points which are snapped together on the shortest proximal distance.
Map 2: The complete African Road Network

Map 3: Segment Map of the complete network

The influence of road network centrality on FDI attraction in Africa
Network Betweenness and Network Integration of the African highway system.

Map 4: Network Betweenness

Network integration is a measure of the number of turns from each line that have to be taken to reach other lines (Ståhle et al, 2018). It can be seen in Map 4; where there are darker shades are where the road network is denser. The lighter the shade, the less dense the road network is. It is visibly seen that most FDI locations are where the shade is darker, meaning the road network is denser and there is a higher connectivity of places. The darker areas can be seen as largely forming two clusters, the upper far north and Sub-Saharan Africa. Additionally, areas with high network integration present more options for Transversing the network, as sometimes referred to as choice.

Map 5: Network Integration

Network Betweenness shows the degree to which a road segment appears to be in the shortest path between all pairs of road segments within the network, or the number of shortest paths that cross the line (Ståhle et al, 2018). Such road segments, as seen in Map 5, with a high betweenness value exert control over movement and connections between other road segments in
the network. Such road segments, as literature suggests (Gutierrez and Urbano, 1996) should have a high
affinity for economic activities. One can see that areas within the vicinity of the TAH highways also have high foreign investment locations. The TAH highways majorly connect capital cities and majority of African capital cities attract a form of foreign investments.

Reach, Betweenness, Closeness and Straightness, Attraction Reach and Distance

Maps 6: Above: Cities by a) Reach b) Betweenness

Most cities score high in Reach, Straightness and Attraction Reach centrality measures. However, as you compare Reach and Straightness, Reach is more evenly distributed across the geographical scale, but for straightness, most of the high scores are on cities located along or in close proximity of the Trans African Highways. This depicts the ability of cities benefiting in their access to direct connectivity of other cities due to the TAH highways.

Betweenness centrality has low values, which still shows that infrastructure connectivity is still low, therefore, cities are not well inter-linked. Clusters of higher values can be seen in the North area, the West and East of Africa. Strikingly, betweenness at the South of Africa is scattered and not clustered amongst cities. Majority of the cities with a high score of betweenness are at the centre of the network and not at the edges closer to the oceans.

Maps Below: 6c) Straightness d) Attraction Distance 30Km of Trans Highway cities e) Attraction Distance and f) Attraction Reach respectively
The influence of road network centrality on FDI attraction in Africa
Cities situated in the Northern countries as well display high straightness scores than all other cities in the continent. Important to note is that most Northern African cities especially those closer to the oceans (port-cities) have higher scores of all centrality measures except for Betweenness. This could be explained by the proximity of these countries to the global South and their better road infrastructure. The Trans African highways influence over the centrality scores of the cities can be visually seen as there is a trend of higher scores along these corridors as opposed to cities on other road connections.

4.3 Inferential Analysis: Total FDI

The fit of the Instrumental Variable

A single instrumental variable was selected to be used for all the main significant endogenous regressors. This is the Transport Composite Index. It was used in 3 separate models, namely; the current road network, the Trans-Highways model and the modelled network. In two of the models, a single main variable which was significant which was instrumented. In the other model, two endogenous variables were significant and they were instrumented separately. In all the models, the correlation of the instrumental variable with the endogenous variables was positive with coefficients ranging from 0.30 to 0.37 depicting a moderate positive relationship. The Transport Composite index is developed by the AfDB and is a bulk measure of the road network per km. The spatial extent of the road network can be estimated from this index, therefore, it is seen as a proxy for the centrality measures which are calculated based on physical connectivity of the roads. The Index is later tested on its correlation with the error terms which shows to be negative at a negligible level. The literature review in Chapter 2 showed that transport infrastructure is important for foreign investments. The reader might question how this is controlled for in the model. We used the Global Competitiveness Index, a metric that also incorporates infrastructure quality and capacity indicators. Therefore, the relationship is accounted for.

Model 1- Current Road Network (All Major Roads)

The current road network consists of major roads and missing links of the Trans African Highways. Out of all centrality measures tested, three show varying levels of significance. They are Reach at N-Km Radius to other cities, Attraction Reach 360° to the whole road network and Attraction Distance 360°.

Reach shows robust significance at 1% confidence level (-5.85e-07) depicting a negative relationship (Model 1, R-squared= 0.20, 236 observations). The highly significant relationship shows that the reach of a city to other cities within the network is an important factor of consideration for multi-national enterprises. Although Reach displays negative relationship, this shows that Africa still lags behind in terms of the connectivity of each city to all other cities within the continent. Sections over the Sahara desert are very weakly developed creating a sort of gap between Northern countries and Sub-Saharan countries. The reach computed from smaller geographical extents such as 30Km and 100Km do not impact on the y-variable. Therefore, in this network, of significance is the reach of one city to others across the continent and not to other cities within closer geographical extent. The other two variables, which showed significance, though at a weak 10% are Attraction Reach to the whole road network (0.370) and...
The influence of road network centrality on FDI attraction in Africa

Attraction Distance (0.370). They both have a positive relationship with foreign investment attraction.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The reach of a city to all others across the continent has the potential of decreasing FDI by about -5.85e-07%. Although depicting a negative weak coefficient sign, reach is significant for foreign investments. It is hard to disqualify the hypothesis that the centrality measure positively influences foreign investment attraction. This could be attributed to the fact that the complete Trans-African highways are not included in the model, highlighting the role of the highways. Attraction Distance and Attraction Reach, though not strongly significant, both have the potential to increase FDI by 0.37%.

Comparison of OLS and 2SLS Estimates

<table>
<thead>
<tr>
<th>Variables</th>
<th>(OLS) logTotalFDI</th>
<th>(2SLS) logTotalFDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log AD-360°</td>
<td>0.320</td>
<td>1.365**</td>
</tr>
<tr>
<td></td>
<td>(0.206)</td>
<td>(0.636)</td>
</tr>
<tr>
<td>Reach</td>
<td>-5.85e-07***</td>
<td>3.72e-06</td>
</tr>
<tr>
<td></td>
<td>(1.09e-07)</td>
<td>(3.15e-06)</td>
</tr>
<tr>
<td>Log Population</td>
<td>0.105</td>
<td>3.580</td>
</tr>
<tr>
<td></td>
<td>(0.152)</td>
<td>(2.600)</td>
</tr>
<tr>
<td>GDP</td>
<td>5.42e-05</td>
<td>-0.000629</td>
</tr>
<tr>
<td></td>
<td>(5.78e-05)</td>
<td>(0.000650)</td>
</tr>
<tr>
<td>Log GCI</td>
<td>0.994</td>
<td>15.35</td>
</tr>
<tr>
<td></td>
<td>(1.725)</td>
<td>(14.48)</td>
</tr>
<tr>
<td>Log Trade%GDP</td>
<td>-0.194</td>
<td>0.212</td>
</tr>
<tr>
<td></td>
<td>(0.848)</td>
<td>(1.003)</td>
</tr>
<tr>
<td>Constant</td>
<td>111.6***</td>
<td>-769.3</td>
</tr>
<tr>
<td></td>
<td>(22.13)</td>
<td>(649.2)</td>
</tr>
</tbody>
</table>
The influence of road network centrality on FDI attraction in Africa

Observations 236 236
R-squared 0.219 0.344

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Box 1: Endogeneity Results of the current road network model

. estat endog

Tests of endogeneity
Ho: variables are exogenous

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durbin (score) chi2(1)</td>
<td>2.02113</td>
<td>0.1551</td>
</tr>
<tr>
<td>Wu-Hausman F(1,40)</td>
<td>1.75831</td>
<td>0.1924</td>
</tr>
</tbody>
</table>

The P-Value for the endogeneity test depicts a value of 0.1924, higher than 0.05, therefore we fail to reject the hypothesis that the regressors in the equation are endogenous. In that regard, therefore, we conclude that there is no presence of endogeneity in the model.

A comparison of the OLS and 2SLS models shows a probability of 0.1889, thus we fail to reject hypothesis that the difference in the coefficients of the two models are not systemic. This thus shows that OLS is more efficient as an estimator than 2SLS. The latter model is efficient under both Ho and Ha (these results are annexed at the end of this report). The R-squared of the 2SLS model is 0.34 whereas OLS shows an R-Squared of 0.22. For the final models, one X-variable (Log AR-360° Whole Network) is left out due to collinearity with Log AD-360°.

Model 2- Trans African Highways:

To show the influence of the TAH highways have on the economic function of cities, cities that were within 10Km radius of each of these highways was selected. These were about 141 cities but based on the full availability of other variables data.

A number of centrality measures were performed: Reach, Betweenness, Straightness, Attraction Distance and Attraction Reach. The results below show the significant results output.

Attraction Reach Centrality

To measure Attraction Reach, a number of tests were carried out on different variations on the destination objects (other cities or the road network itself) and on the radius type (straight line-Km, angular radius-360 °). Straight line distances were measured for 30Km, 100Km and 10,000Km. The most significant results were for Attraction Reach within 360° radius. This measure shows the number of attractions reached from one origin point (the TAH cities) to other destinations but within 360° extent. The significance of this measure is at 1% confidence level (0.174) see model 5 (111 observations, R2=0.30). The coefficient is positive which shows that as the relationship between this measure and FDI attraction is positive. The higher the attractions reached from each city, the higher the affinity for attracting foreign investments. It is important to note that, the Trans African Highways were considered as complete connections as opposed to the existing situation, which has missing links. The improvement of the network resulted in an increase of the reach of the cities within 10Km radius of the TAH to all other cities in the network. Population size is constantly significant which shows that majority of foreign
investments are motivated by a large market size and labor availability. Global Competitiveness Index is also positively significant (Model 5, 2.642) although at a 10% confidence level.
Betweenness Centrality

Betweenness shows the measure of the number of times each city lies in the shortest paths of pairs of city connections within different radiuses. A measure of 30Km, 100Km and n-Km was measured, however, significance of these measure was depicted at 100Km as shown in the table below.

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log TotalFDI</td>
<td>Log TotalFDI</td>
<td>Log TotalFDI</td>
<td>Log TotalFDI</td>
<td>Log TotalFDI</td>
</tr>
<tr>
<td>Attraction Reach 360°</td>
<td>0.145**</td>
<td>0.0959*</td>
<td>0.172***</td>
<td>0.168***</td>
<td>0.174***</td>
</tr>
<tr>
<td></td>
<td>(0.0616)</td>
<td>(0.0563)</td>
<td>(0.0641)</td>
<td>(0.0550)</td>
<td>(0.0549)</td>
</tr>
<tr>
<td>Log Population</td>
<td>0.610***</td>
<td>0.693***</td>
<td>0.715***</td>
<td>0.734***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.107)</td>
<td>(0.121)</td>
<td>(0.136)</td>
<td>(0.142)</td>
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</tr>
<tr>
<td>Log GCI</td>
<td>2.921</td>
<td>3.052**</td>
<td>2.642*</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>(1.790)</td>
<td>(1.393)</td>
<td>(1.433)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log Trade%GDP</td>
<td>0.463</td>
<td>0.598</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.626)</td>
<td>(0.643)</td>
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<tr>
<td>GDP</td>
<td>6.86e-05</td>
<td></td>
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<tr>
<td></td>
<td>(6.62e-05)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>4.548***</td>
<td>-2.987**</td>
<td>-8.197***</td>
<td>-10.35**</td>
<td>-10.74***</td>
</tr>
<tr>
<td></td>
<td>(0.279)</td>
<td>(1.346)</td>
<td>(2.906)</td>
<td>(3.986)</td>
<td>(4.057)</td>
</tr>
<tr>
<td>Observations</td>
<td>141</td>
<td>141</td>
<td>111</td>
<td>111</td>
<td>111</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.038</td>
<td>0.221</td>
<td>0.291</td>
<td>0.294</td>
<td>0.299</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
At 100Km radius, it depicts a strong negative relationship between these two aspects (-2.94e-07) as model 5 shows with an R-squared of 27%. These results show the importance of the strategic location of cities. Within a lower kilometre radius, many of the cities are within the path of other city connections, however, logically as the geographic extent increases; then the road network is extensively covering more cities, which are within the paths of other pairs of cities. Even though it is a negative coefficient, this could imply a weakness in the between connectivity of cities at large within Africa. Population remains a positive significant factor in foreign investments even for this measure of centrality.

### Straightness Centrality

Straightness is a measure of how closely the shortest distances between each city and other cities within a certain defined radius resemble Euclidean distances. For a measure of this centrality within 30Km, 100Km and n radius, 100Km proved to be important. The results are shown in the table below. As the regression starts with the y and x variable, there is a weak (-1.75e-07) negative relationship (Model 1, 10% confidence level), however when other control variables are included in the model, then the significance increases to 5% at (-1.63e-07) as seen in model 5. The negative relationship between Straightness and foreign investments depicts a situation where movement from one city to the other is not a direct connection but rather through other areas. This emphasizes on the requirement of direct city connectivity for foreign investments. The model is explained by an R-squared of about 27%.

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1) logTotal_FDI</th>
<th>(2) logTotal_FDI</th>
<th>(3) logTotal_FDI</th>
<th>(4) logTotal_FDI</th>
<th>(5) logTotal_FDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>100Km Straightness</td>
<td>-1.75e-07*</td>
<td>-1.05e-07</td>
<td>-1.07e-07</td>
<td>-1.79e-07***</td>
<td>-1.63e-07**</td>
</tr>
<tr>
<td></td>
<td>(1.03e-07)</td>
<td>(9.33e-08)</td>
<td>(7.00e-08)</td>
<td>(5.99e-08)</td>
<td>(7.05e-08)</td>
</tr>
<tr>
<td>Log Population</td>
<td>0.623***</td>
<td>0.620***</td>
<td>0.697***</td>
<td>0.721***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.107)</td>
<td>(0.118)</td>
<td>(0.131)</td>
<td>(0.146)</td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>-1.08e-05</td>
<td>1.45e-05</td>
<td>2.59e-05</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(6.38e-05)</td>
<td>(7.11e-05)</td>
<td>(7.40e-05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log GCI</td>
<td>2.412</td>
<td>2.453</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log Trade%GDP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.409</td>
</tr>
<tr>
<td>Constant</td>
<td>5.174***</td>
<td>-2.733**</td>
<td>-2.681*</td>
<td>-6.908***</td>
<td>-8.814*</td>
</tr>
<tr>
<td></td>
<td>(0.181)</td>
<td>(1.374)</td>
<td>(1.560)</td>
<td>(2.873)</td>
<td>(4.461)</td>
</tr>
<tr>
<td>Observations</td>
<td>141</td>
<td>141</td>
<td>141</td>
<td>111</td>
<td>111</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.020</td>
<td>0.212</td>
<td>0.212</td>
<td>0.266</td>
<td>0.268</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

When all the centrality measures are used in a single model, only Attraction Reach and Betweenness remain significant. Attraction Reach has the potential of increasing foreign investment.
The influence of road network centrality on FDI attraction in Africa

investments by about 0.19% whereas Betweenness reduces foreign investment attraction by a weak coefficient of -3.55e-07%.

### Comparison of OLS and 2SLS Estimates

<table>
<thead>
<tr>
<th>Variables</th>
<th>(OSLS) logTotal_FDI</th>
<th>(2SLS) logTotal_FDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attraction Reach 360</td>
<td>0.187*** (0.0549)</td>
<td>7.234 (6.944)</td>
</tr>
<tr>
<td>100Km Betweenness</td>
<td>-3.55e-07** (6.71e-08)</td>
<td>-2.66e-06 (2.28e-06)</td>
</tr>
<tr>
<td>Log Population</td>
<td>0.704*** (0.143)</td>
<td>-0.719 (1.410)</td>
</tr>
<tr>
<td>GDP</td>
<td>5.88e-05 (6.65e-05)</td>
<td>0.000776 (0.000713)</td>
</tr>
<tr>
<td>Log GCI</td>
<td>2.854** (1.429)</td>
<td>17.21 (14.28)</td>
</tr>
<tr>
<td>Log Trade%GDP</td>
<td>0.475 (0.640)</td>
<td>-6.259 (6.654)</td>
</tr>
<tr>
<td>Constant</td>
<td>-10.16** (4.071)</td>
<td>-12.25** (4.941)</td>
</tr>
</tbody>
</table>

Observations: 111
R-squared: 0.321 (OSLS) 0.274 (2SLS)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Box 2: Endogeneity results for Trans-African Highways model

```
. estat endog
Tests of endogeneity
Ho: variables are exogenous

Durbin (score) chi2(1) = 1.22812 (p = 0.2678)
Wu-Hausman F(1,103) = 1.15236 (p = 0.2856)
```

The P-Value (0.2856) is more than 0.05 therefore, we fail to reject hypothesis. The regressors in the equation are exogenous, thus there is no presence of endogeneity in the model. The relationship of the variables under study occurs in one-sided, that is, to say; network centrality influences foreign investment attraction and not vice-versa.

The test from the general version of the Haussmann test, which should depict the consistency between the two models, shows a P-Value of 0.2834. This is larger than 0.05, thus, we thus fail to reject hypothesis. Under H0, both OLS and 2SLS are consistent therefore OLS model is more efficient, and the difference in the coefficients is not systemic. The R-Squared decreases from 0.32 (OLS) to 0.27 (2SLS).
Model 3- Modelled Network (New Connections)

To compare and understand the impact of new physical connections, a network was drawn by linking up land-locked country-cities and prominent port-cities plus the Trans Highways. Robust outcomes of increased centralities showed strong correlation under this model. Reach at n-radius, Betweenness at 100Km radius and Attraction Distance at 100Km to TAH cities and to all other cities plus attraction distance at 360 showed significance. Negative robust significance were displayed by Reach, Betweenness and Attraction Distance 360 (Model 6, -6.30e-07, -2.50e-07, -0.00618) respectively. Attraction Distance to the Tah cities and to other cities in the network showed highly positive significance (1%) with coefficients of 9.313 and 2.708 respectively. The R-squared the model with all centralities is 0.29 with 246 cities as observations. The results are as in the table below. Population and GDP are constant significant factors showing the relevance of labour availability and economic performance in attracting foreign investments.

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1) logTotalFDI</th>
<th>(2) logTotalFDI</th>
<th>(3) logTotalFDI</th>
<th>(4) logTotalFDI</th>
<th>(5) logTotalFDI</th>
<th>(6) logTotalFDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reach</td>
<td>-6.73e-07***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-6.30e-07***</td>
</tr>
<tr>
<td></td>
<td>(1.46e-07)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.41e-07)</td>
</tr>
<tr>
<td>Log Population</td>
<td>0.227*</td>
<td>0.591***</td>
<td>0.581***</td>
<td>0.594***</td>
<td>0.590***</td>
<td>0.244*</td>
</tr>
<tr>
<td></td>
<td>(0.125)</td>
<td>(0.0967)</td>
<td>(0.0972)</td>
<td>(0.0963)</td>
<td>(0.0965)</td>
<td>(0.124)</td>
</tr>
<tr>
<td>GDP</td>
<td>0.000106**</td>
<td>0.000102**</td>
<td>0.000111**</td>
<td>0.000114**</td>
<td>0.000107**</td>
<td>0.000102**</td>
</tr>
<tr>
<td></td>
<td>(4.31e-05)</td>
<td>(4.59e-05)</td>
<td>(4.61e-05)</td>
<td>(4.55e-05)</td>
<td>(4.56e-05)</td>
<td>(4.25e-05)</td>
</tr>
<tr>
<td>Log GCI</td>
<td>-0.488</td>
<td>-0.376</td>
<td>-0.450</td>
<td>-0.421</td>
<td>-0.660</td>
<td>-0.678</td>
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<tr>
<td></td>
<td>(1.193)</td>
<td>(1.165)</td>
<td>(1.186)</td>
<td>(1.173)</td>
<td>(1.178)</td>
<td>(1.179)</td>
</tr>
<tr>
<td>Log Trade%GDP</td>
<td>0.505</td>
<td>0.588</td>
<td>0.526</td>
<td>0.487</td>
<td>0.536</td>
<td>0.514</td>
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<tr>
<td></td>
<td>(0.467)</td>
<td>(0.471)</td>
<td>(0.476)</td>
<td>(0.475)</td>
<td>(0.476)</td>
<td>(0.459)</td>
</tr>
<tr>
<td>Betweenness 100Km</td>
<td>-2.76e-07***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-2.50e-07***</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>(4.38e-08)</td>
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<tr>
<td>Attraction Distance 100KmTah</td>
<td>9.744***</td>
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<td></td>
<td></td>
<td></td>
<td>9.313***</td>
</tr>
<tr>
<td></td>
<td>(1.865)</td>
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<td></td>
<td></td>
<td></td>
<td>(2.280)</td>
</tr>
<tr>
<td>Attraction Distance 100Km Whole</td>
<td>2.397***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.708***</td>
</tr>
<tr>
<td></td>
<td>(0.516)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.451)</td>
</tr>
<tr>
<td>Attraction Distance 360</td>
<td>-0.00534**</td>
<td>-0.00618**</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>(0.00264)</td>
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<tr>
<td>Constant</td>
<td>127.8***</td>
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<td>-4.628</td>
<td>-4.233</td>
<td>-3.765</td>
<td>119.2***</td>
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<tr>
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<td>(29.26)</td>
<td>(2.909)</td>
<td>(2.915)</td>
<td>(2.904)</td>
<td>(2.948)</td>
<td>(28.21)</td>
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<td>Observations</td>
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<td>246</td>
<td>246</td>
<td>246</td>
<td>246</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.221</td>
<td>0.187</td>
<td>0.171</td>
<td>0.176</td>
<td>0.174</td>
<td>0.290</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Comparison of OLS and 2SLS estimates

<table>
<thead>
<tr>
<th>Variables</th>
<th>(OLS) logTotalFDI</th>
<th>(2SLS) logTotalFDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reach</td>
<td>-6.30e-07***</td>
<td>6.13e-06</td>
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<td>(1.41e-07)</td>
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<tr>
<td>Betweenness 100Km</td>
<td>-2.50e-07***</td>
<td>-3.96e-07*</td>
</tr>
<tr>
<td></td>
<td>(4.38e-08)</td>
<td>(2.34e-07)</td>
</tr>
<tr>
<td>Attraction Distance 100KmTah</td>
<td>9.313***</td>
<td>6.320</td>
</tr>
<tr>
<td></td>
<td>(2.280)</td>
<td>(6.535)</td>
</tr>
<tr>
<td>Attraction Distance 100Km Whole</td>
<td>2.708***</td>
<td>5.689</td>
</tr>
<tr>
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<td>(0.451)</td>
<td>(4.342)</td>
</tr>
<tr>
<td>Attraction Distance 360</td>
<td>-0.00618**</td>
<td>-0.0139</td>
</tr>
<tr>
<td></td>
<td>(0.00239)</td>
<td>(0.0115)</td>
</tr>
<tr>
<td>Log Population</td>
<td>0.244*</td>
<td>3.791</td>
</tr>
<tr>
<td></td>
<td>(0.124)</td>
<td>(5.231)</td>
</tr>
<tr>
<td>GDP</td>
<td>0.000102**</td>
<td>0.000134*</td>
</tr>
<tr>
<td></td>
<td>(4.25e-05)</td>
<td>(7.02e-05)</td>
</tr>
<tr>
<td>Log GCI</td>
<td>-0.678</td>
<td>-0.477</td>
</tr>
<tr>
<td></td>
<td>(1.179)</td>
<td>(1.360)</td>
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<tr>
<td>Log Trade%GDP</td>
<td>0.514</td>
<td>0.594</td>
</tr>
<tr>
<td></td>
<td>(0.459)</td>
<td>(0.510)</td>
</tr>
<tr>
<td>Constant</td>
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<td>(28.21)</td>
<td>(1.944)</td>
</tr>
<tr>
<td>Observations</td>
<td>246</td>
<td>239</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.290</td>
<td>0.234</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Box 3: Endogeneity Results of the Modelled network

. estat endog

Tests of endogeneity
Ho: variables are exogenous

Durbin (score) chi2(1) = 0.517425 (p = 0.4719)
Wu–Hausman F(1, 228) = 0.494681 (p = 0.4826)

To test for endogeneity, two significant variables were used, Reach and Attraction Distance 100Km, and the same instrumental variable, in separate models. The Wu Haussmann results for both variables show a similar P-value of 0.4826. This is higher than 5%, therefore, we fail to reject the hypothesis that these regressors are exogenous, and concluding that there is absence of endogeneity in the model.

A comparison of the two models 2SLS and OLS, shows that the difference in the coefficients of the regressors are not systemic based on a P-value of 0.2916. The OLS model is efficient under the null hypothesis; therefore, it is a more consistent model than 2sls and a better estimator of the
association between the aspects under study. The R-Squared decreases from 0.29 in OLS to 0.23 in 2SLS model.

**Justification for choice of the modelled network**

Most of the foreign investments in Africa occurs in industrial/manufacturing activities. In light of this: we decided to link up direct straight-line connectivity of the top receiving high manufacturing foreign investments and service centres. Most service centres in Africa are capital cities. Research by PIDA and ICA show that Africa is losing well over 2% -3% of its GDP due to poor connectivity (ICA, 2015). Additionally, logistics in landlocked countries performs poorly due to lack of connectivity to ports, which are hubs to most trade activities. This forms the justification for creating a corridor connecting the major cities in the land-locked countries and then connecting this corridor to port-cities. Therefore, we chose the top receiving FDI cities within the 16 land-locked countries and created a land-locked country corridor. These are mostly capital cities and secondary cities. The other model of enhancing connectivity was linking major port-cities to these cities in the landlocked countries, or at least to other cities closer to the port-cities but which have a connection with the land-locked countries cities. The cities connected are shown in the next chapter.

The maps below show the influence of the modelled connectivity network on centrality measures for the cities. As depicted by the maps 1-6 below, the new connections have an influence over the ability of more cities to have an increased centrality measure to other cities within the continent. The reach measure as seen by the size of the node at each city shows a higher reach after the new connections for the same cities as compared to prior before the new model network.

The same can be said for Straightness and Betweenness. The cities at the centre of new connections have an increased value of straightness as depicted by the size of the node. This shows that these cities then have more connections closer to Euclidean distances, thus they have increased direct connections to other cities. As for betweenness, the cities in general have an increased value in this measure and more of the new connected cities are now in the path of more pairs of cities.

There are 16 land-locked countries in the continent. The major cities with high values of FDI in these countries made up the land-locked corridor in Map 7, whereas in Map 8, the major ports in close proximity to these in-land cities were connected to the existing corridor.
Map 7: The land-locked countries-cities corridor

Map 8: Port city- Inland City (land-locked countries) Connectivity

The influence of road network centrality on FDI attraction in Africa
The maps above show the difference in the betweenness values of the cities connected by the highlighted connections. The cities now have a higher value of betweenness and the number of shortest-path inter-city connections that pass through them is higher. The betweenness increases by an average of 37.5%. Cities at the edges of the African continent; the port-cities are not affected highly by these connections as compared to more in-land cities.
The scenario is similar to the reach measure. Once the new connections are generated, the cities along the corridor increase their values of reach, showing that from each city, the number of other cities reached within a short distance path is higher. Reach values increase by approximately 88%, and had been seen in earlier statistical regressions are very significant with the dependent variable, foreign investments.
After the new connections, the cities connected have a higher straightness value which increases at an average of 51%. This shows that connectivity between these cities and others within n-radius now is more direct as if resembling Euclidean distances. Both port-cities and in-land cities are affected in this measure of centrality and they all increase alike.
Trans African Highways Versus Current road network

This comparison is done through OLS statistical results: Some of the centrality measures showed very significant outcomes; however, they had weak coefficients and some negative coefficients. A previous study by Wall et al. (2018) on the comparison of road connectivity in the Lagos-Abidjan corridor and the Europe corridor showed that significance levels are higher in Africa, however, the coefficients were lower or negative due to weak road network infrastructure.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Current Road Network</th>
<th>Road Network with Trans-African Highways</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff. Sign</td>
<td>Significance</td>
</tr>
<tr>
<td>Reach Area</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>Betweenness 100Km</td>
<td>+</td>
<td>X</td>
</tr>
<tr>
<td>Attraction Reach Angular 360</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Attraction Distance 100Km radius</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Attraction Distance 10000Km</td>
<td>+</td>
<td>X</td>
</tr>
<tr>
<td>Attraction Distance 360</td>
<td>+</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 8: Comparison Summary: Current Road Network and Inclusive of the highways

The results show that with the current road network, only one independent variable, Reach by infinite radius is significant for the cities attraction of FDI. In comparison to the whole road network, five independent variables are now significant, that is, Attraction Distance by 100Km, 10000Km and 360 angle, Betweenness and Attraction Reach. For attraction Reach by 360 angle and Attraction Distance 100Km, we can see that when the Trans highways are not included in the model, there is a negative correlation with foreign investments, however, when the TAH highways are added into the network, we see this centrality measure becoming very significant and additionally, it becomes positively correlated with foreign investments.

This proves the hypothesis that when the centrality measures are evaluated with whole highway network, we establish that road network centrality is significant for foreign investments attraction.
Population, Global Competitiveness Index as a whole and GDP, Trade % of GDP are used as control variables. Population shows strong significance for all the models, without the Trans Highways in the model and with their inclusion. It also has positive coefficients, which is true to literature which shows that highly populated regions have a higher affinity for economic activities in this case, foreign investments. Investors need a market for their products or affordable labour for their production activities, therefore, a higher populated area will likely be preferable (Asiedu, 2002, Anyanwu and Erhijakpor, 2004).

The Global Competitiveness Index comprises of 12 pillars which have been globally accepted as defining a country’s economic competitiveness. The index was used a whole for all the factors are important as established by literature as important for foreign investments attraction. However, a caveat is that since the analysis was carried out on city level, each country’s index whose city was included in this analysis was set to represent the city’s competitiveness. This obviously has some bias, since different cities which happen to be in one country would have the same competitiveness index. Lack of availability of this data is the reason behind this application. This was same for GDP and Transport Composite Index, which is used as an Instrumental Variable for the analysis.

4.4 Inferential Analysis: Sectoral FDI

Sectoral FDI in the Current Road network

As for the centrality measures derived from the Road network without the complete Trans-Highways, not all the tested independent variables had significance, except for Reach, Straightness and Attraction Reach. Reach was highly significant, however negatively in two sectors, namely manufacturing and services. The results showed robust significance at 1% confidence level as seen in models 1, 2. The R-squared are also significantly high at 66% for Services FDI and 46% for Manufacturing FDI. Hi-Tech and Resources sector results are only explained with 0.07% and 0.02% R-squared. The centrality measures are not significant, likely because of the absence of the Trans African highways; therefore, most scores were extremely low. In contrast, Reach is not significant for both of these sectors. The only significant variable for Hi-Tech sector is Attraction Reach at 360, which shows a confidence level of 5%, however negatively correlated. Straightness also shows a positive robust relationship on Resources FDI (1% confidence level, 0.0273). Population a proxy for labour availability is only significant for Hi-Tech FDI whereas trade openness proves to be highly positively significant for Services FDI. On cities not trans-versed by the Trans-Highways, it seems this could be a motivating factor for the attraction of FDI.

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1) Manufacturing FDI</th>
<th>(2) Services FDI</th>
<th>(3) Hi-Tech FDI</th>
<th>(4) Resources FDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reach</td>
<td>-0.000498***</td>
<td>-0.000479***</td>
<td>10.74***</td>
<td>2.488</td>
</tr>
<tr>
<td>Log Population</td>
<td>-31.41</td>
<td>-44.66</td>
<td>34.99</td>
<td>(3.754)</td>
</tr>
<tr>
<td>GDP</td>
<td>0.0128</td>
<td>0.00718</td>
<td>-0.000448</td>
<td>0.00757</td>
</tr>
<tr>
<td>Log GCI</td>
<td>-12.47</td>
<td>334.0</td>
<td>50.99</td>
<td>-65.25</td>
</tr>
</tbody>
</table>

The influence of road network centrality on FDI attraction in Africa
The influence of road network centrality on FDI attraction in Africa

<table>
<thead>
<tr>
<th>Variables</th>
<th>(2) Hi-Tech FDI</th>
<th>(4) Manufacturing FDI</th>
<th>(6) Services FDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log Population</td>
<td>11.19*</td>
<td>0.567***</td>
<td>0.836***</td>
</tr>
<tr>
<td></td>
<td>(5.871)</td>
<td>(0.114)</td>
<td>(0.120)</td>
</tr>
<tr>
<td>GDP</td>
<td>-0.00228</td>
<td>3.79e-05</td>
<td>3.63e-05</td>
</tr>
<tr>
<td></td>
<td>(0.00167)</td>
<td>(7.46e-05)</td>
<td>(7.77e-05)</td>
</tr>
<tr>
<td>Log GCI</td>
<td>114.2***</td>
<td>1.835</td>
<td>0.962</td>
</tr>
<tr>
<td></td>
<td>(42.88)</td>
<td>(1.788)</td>
<td>(1.493)</td>
</tr>
<tr>
<td>Log Trade%GDP</td>
<td>-16.79</td>
<td>-0.813</td>
<td>1.413**</td>
</tr>
<tr>
<td></td>
<td>(20.16)</td>
<td>(0.670)</td>
<td>(0.587)</td>
</tr>
<tr>
<td>Betweenness 100Km</td>
<td>-2.80e-06**</td>
<td>-1.32e-07***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.27e-06)</td>
<td>(4.75e-08)</td>
<td></td>
</tr>
<tr>
<td>Reach</td>
<td>-8.84e-09***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.15e-09)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Sectoral FDI in Trans African Highways Cities:

For cities at a 10Km radius of the Trans African Highways, a number of variables are significant for several sectors. Resources FDI, however did not have any significant variables. Reflecting back on the descriptive analysis as in map 1a, one can see that Resources FDI is very low on the cities along/close to the Trans African highways. Quite a number of variables were significant, positively and negatively. Reach at at n-radius is only significant for manufacturing sector. It is negatively significant at 1% confidence level (-8.84e-09, 68 observations, R-squared of 0.32). Betweenness at 100Km radius is significant at 5% confidence level for Hi-Tech and 1% confidence level for Services FDI, however they have negative coefficients (-2.80e-06 and -1.32e-07) respectively. The variables attraction distance 30Km and attraction reach 360 are significant, however, for Services FDI only and at 10% and 5% confidence levels respectively. Straightness is strongly positively significant for Manufacturing sector. The models have an R-squared of about 47%. Population is positively significant for all the sectors at 1% confidence level for Hi-Tech sector whereas 1% significance for both manufacturing and services sectors. This shows that for all these sectors labour availability is a key motivation for investing. Trade% of GDP, the proxy for trade openness has robust significance for the services sector, using 92 observations.
The influence of road network centrality on FDI attraction in Africa

<table>
<thead>
<tr>
<th>Centrality Measure</th>
<th>30Km</th>
<th>100Km</th>
<th>n-Km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straightness</td>
<td>3.52e-06***</td>
<td>12.07*</td>
<td>0.114**</td>
</tr>
<tr>
<td>Attraction Distance</td>
<td>12.07*</td>
<td>0.114**</td>
<td></td>
</tr>
<tr>
<td>Attraction Reach</td>
<td>0.114**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-201.7</td>
<td>-0.449</td>
<td>-13.87***</td>
</tr>
<tr>
<td>Observations</td>
<td>112</td>
<td>68</td>
<td>92</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.098</td>
<td>0.315</td>
<td>0.499</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Sectoral FDI in the Modelled Network**

An analysis of the different centrality measures of the complete road network with new connections showed variations in the different sectors. The reach centrality is very strongly significant for both the manufacturing and services sectors however with negative coefficients. The table below shows that reach is significant at 1% confidence levels as seen in models 1 (-4.05e-07, R-squared 0.18, 137 observations) and 4 (-4.58e-07, R-squared 0.49, 86 observations) below.

Betweenness measures at 30Km, 100Km and n-Km radii were evaluated. Betweenness at 100Km displayed robust positive significance for the Services sector (1% confidence level, 9.81e-08, 0.49% R-squared). For the Hi-Tech and Resources sectors, betweenness at infinite radius also shows robust positive significance. Resources sector depicts 5% confidence level of the regressor with a positive coefficient of 16.34, however with a weak r-squared percentage of 0.07. On the other hand, the Hi-Tech sector shows a robust negative relationship (1%) between betweenness and foreign investments (-7.06e-09, 0.14 R-Squared). This shows that for these sectors, the chance of a city being in the paths of other city connections within a larger radius, i.e. at a larger geographical extent, is a relevant factor. In contrast, for the Services sector, betweenness at 100Km-radius showed positive strong significance, which shows that for this sector; investors prefer cities that are within the paths of other cities locally, or on a smaller geographical scope. The global competitiveness index is also very positively significant for the Hi-Tech sector with a coefficient of 157.4 as seen in model 3 below. Trade % of GDP which is a proxy for trade and investment openness is very significant for the Services and Resources sectors with positive coefficient.

The attraction distance measure at 30Km radius to other Trans-African cities shows significance at 5% confidence level for Manufacturing Sector FDI. Model 2 shows positive coefficient of 0.102 with 137 observations, however the R-squared is low at 18%. The higher the score for attraction distance, it shows that that city has a high affinity for reaching many other cities through the most short distance.

Population is significant in all sectors except for Resources FDI. However, for manufacturing FDI, it is only significant when the centrality measure under study is Attraction Distance. This is probably because for multinational enterprises investing in the resources sector will seek where the resources are existent, and this may happen in remote areas where there are no agglomerations of people. The other FDI sectors have a need for areas where there is labour availability and market for the products and services.
These results are depicted in the following table.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Manufacturing FDI</th>
<th>Hi-Tech FDI</th>
<th>Resources FDI</th>
<th>Services FDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reach</td>
<td>-4.05e-07***</td>
<td>-4.58e-07***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(9.89e-08)</td>
<td>(1.09e-07)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attraction Distance 30Km</td>
<td>0.102**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0449)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log Population</td>
<td>0.0667**</td>
<td>16.12***</td>
<td>24.57</td>
<td>0.366***</td>
</tr>
<tr>
<td></td>
<td>(0.119)</td>
<td>(5.372)</td>
<td>(16.52)</td>
<td>(0.131)</td>
</tr>
<tr>
<td>GDP</td>
<td>0.000109</td>
<td>-0.00539**</td>
<td>0.0106</td>
<td>-5.29e-05</td>
</tr>
<tr>
<td></td>
<td>(6.61e-05)</td>
<td>(0.00230)</td>
<td>(0.0130)</td>
<td>(0.000106)</td>
</tr>
<tr>
<td>Log GCI</td>
<td>-2.035</td>
<td>157.4***</td>
<td>85.56</td>
<td>-0.0733</td>
</tr>
<tr>
<td></td>
<td>(1.687)</td>
<td>(59.86)</td>
<td>(179.3)</td>
<td>(1.715)</td>
</tr>
<tr>
<td>Log Trade%GDP</td>
<td>0.347</td>
<td>-10.81</td>
<td>46.91*</td>
<td>1.482***</td>
</tr>
<tr>
<td></td>
<td>(0.554)</td>
<td>(19.35)</td>
<td>(23.65)</td>
<td>(0.536)</td>
</tr>
<tr>
<td>Betweenness N-Km</td>
<td>-7.06e-09***</td>
<td>16.34**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.41e-09)</td>
<td>(8.109)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Betweenness 100Km</td>
<td></td>
<td></td>
<td></td>
<td>9.81e-08***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.68e-08)</td>
</tr>
<tr>
<td>Constant</td>
<td>82.08***</td>
<td>-329.6**</td>
<td>-831.9*</td>
<td>81.16***</td>
</tr>
<tr>
<td></td>
<td>(20.66)</td>
<td>(164.8)</td>
<td>(481.5)</td>
<td>(22.28)</td>
</tr>
<tr>
<td>Observations</td>
<td>137</td>
<td>137</td>
<td>98</td>
<td>137</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.179</td>
<td>0.138</td>
<td>0.073</td>
<td>0.494</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Summary of Comparison of the Services, Manufacturing, Resources and Hi-Tech FDI Sectors

Population is very significant for all types of FDI except for resources FDI. This is probably because for multinational enterprises investing in the resources sector will seek where the resources are existent, and this may happen in remote areas where there are no agglomerations of people. The other FDI sectors have a need for areas where there is labour availability and market for the products and services.

Hi-Tech FDI is inclined to be set up where there are developed infrastructure and knowledge institutions. This is mostly in the urban areas where populations are higher and mostly in capital cities and secondary cities. As Jacobs (1961) argued that when people agglomerate together, they share ad exchange ideas, information and creativity is enhanced through concentrated social networks. Resources is the least invested sector in Africa as opposed to common expectation that multinational enterprises invest in Africa due to the resources motives. For the last decade too, Resources FDI has exhibited negative growth that Wall et al. (2018) demonstrate as "strong". They blame this on the falling commodity prices experienced globally.
The influence of road network centrality on FDI attraction in Africa
Chapter 5: Conclusion and Recommendations:

5.1 Introduction:
The analysis of centrality measures of infrastructure in Africa and its relation to foreign investments has led to proof that form influences function. This chapter discusses meaningful conclusions out of the undertaken analysis in the preceding chapter. What is in it for different cities and states in Africa with regards to infrastructure development and what is the way forward from this point? A reflection on the potential of Trans African highways helps to enlighten policymakers and other stakeholders on other possibilities of integrating the continent. These issues make up the content in this final chapter. This chapter also reflects upon the research questions of the research and establishes the answers to these questions. The conclusions thus form a bridge towards the recommendations that can be taken up out of this research.

5.2 Conclusions
As Wall et al (2018) shows that infrastructure connectivity within and between cities is very critical to gauge its potential, we could see that significance levels of cities centrality measures within 30Km and 100Km radius were low. Significance is higher when infinite radius is considered. This clearly depicts poor connectivity within individual countries and within close proximity of the cities.

This research results help to look back at the slow development of road infrastructure network in Africa. The Trans African Highways master plan was instituted in the late 1960s; however over 50 years later, the highways are not anything synonymous with the road infrastructure. A narrative by Clacherty (2017) shows that in most countries, the highways lack signage and recognition so there is hardly any significance attached to the utility of them amongst road users. They lack standardization between different countries where they connect major cities. In addition to missing links, there are sections of the roads where the road quality, size dimensions mismatch. This has major implications on the utility ratio of these roads, thereby influencing the competitiveness and attract-ability of the cities in close proximity of the highways. Road connectivity has been established to have a major influence on economic vibrancy of an area, through bridging connections from developed regions to undeveloped regions, moving goods and people from centres of production to consumption, settlement areas to the working areas: urban centres and industrial areas. Feasibility studies have shown higher benefits over investment into transportation projects (Gutiérrez and Urbano, 1996, Gutiérrez, et al., 2010, Gutiérrez, et al., 2011, Lall, et al., 2017). This research similarly establishes the influence of the spatial extent of road network on cities competitiveness for foreign investments.

The knowledge of centrality measures of different cities in Africa is fundamental in establishing city characteristics, can help to draw up meaningful comparisons between cities and importantly can help to define or shape the role of a city within the continental scale and also globally.

Reflection on the Research Questions:
To what degree do statistically derived ‘network centrality’, measures, of the African road network, affect the ability of major African cities to attract FDI, while controlling for other
explanatory factors, i.e. the Global Competitiveness Index, Population Size, Trade openness and GDP?

**Sub-questions are:**

I. How do the network centrality measures i.e. *reach, betweenness, straightness, attraction reach and distance* help to understand the potential of the African highway system?

II. To what degree do these centrality measures of networks (a) the current African road network, (b) the Trans African Highways (c) the theoretically corrected network; influence the attraction of total FDI to major cities?

III. Based on network analysis techniques, which are the essential weak points in the network that can be developed in future to enhance greater connectivity in Africa?

IV. To what extent do the network centrality measures influence attraction of sectoral FDI into the Manufacturing, Service, Hi-Tech and Resource sectors?

**How do the network centrality measures i.e. *reach, betweenness, straightness, attraction reach and distance* help to understand the potential of the African highway system?**

The significance of the above mentioned indicators on FDI attraction has proved that centrality measures can be used to understand which cities have better economic performance, and why. These measures help one to understand the different characteristics of different cities. Meaningful comparisons can be drawn up between competitor cities by examining each city’s centrality characteristics. A high betweenness value shows that this particular city serves as an intermediary between many other pairs of cities within shorter path distance. Such cities, if connected, could bridge gaps in connecting Africa. Cities with a high betweenness value can serve as regional headquarters. Reach centralities help to define how integrated a city is to other cities, and the influence of this on certain aspects. If, for instance; the physical accessibility of the labour market in Nairobi is approximately 45%, and CapeTown is 65%, if these two cities were connected on the shortest direct paths, the labour market accessibility increases by approximately 37 % to 88% . This is based on the increase of reach, betweenness and straightness centralities on FDI, before and after the connectivity. A city with a high straightness value would be a preferred destination as well as it has more direct connections, guaranteeing less travel-time. Accessibility models can help to establish whether costs can increase or reduce, and by what level.

The fact that quite a number of centrality measures showed very strong significance, either positively or negatively shows that the utility of a road network influences economic activities. Although factors such as technological development and innovation, internet connectivity are necessary for increased investment activity in a region, all matters held constant (ceteris paribus) then you can see that weak transport development is derailing Africa’s competitiveness and attract-ability.

**To what degree do these centrality measures of networks (a) the current African road network, (b) the Trans African Highways (c) the theoretically corrected network; influence the attraction of total FDI to major cities?**

**(a) The Current road network**

The analysis of the road network system with and without the TAH system has proved an important aspect, that the direct connectivity between these cities in different countries is very critical for the economic function of these cities. When the network was considered with
only major roads and incomplete highways, cities prove to have fewer values on the centrality measures. Additionally, the significance levels of the centrality measure reduces.

However, when the TAH highways are included into the network, we can highly see an increase in the R-Squared of the econometric model, from 21% to 32% (see models under current road network and Trans-Highways network) and more centrality measures prove to be significant.

A comparison of trade activities (Trade as % of GDP) happening in these cities too also show that studying the capacity and utility of the African transport network through centrality measures reveals the influence of connectivity on other economic activities in an area. Transport investments would really transform the logistics industry in Africa. Perhaps it would also be necessary to compare these centrality measures between different geographical regions, say the South, West, East and North or through the regional economic blocs.

(b) The Trans African Highways network

We have to point out that when performing the analysis, we assumed all the TAH connections are complete. However, this is not as it is on the ground. Most TAH are not freely flowing between cities and additionally, they are not standardized. This has a major impact on how they are utilized and eventually the competitiveness of cities along or near the TAH highways. This model has more significant centrality variables than both the TAH and Ex-TAH networks.

The potential of the Trans African highways has been established. This should serve as evidence that such inter-city and country connections are very critical. This is important because majority of the countries are still developing or classified under low-income category, therefore, the continent has a very great potential to develop the transport sector. Most of the cities that are trans-versed by these highways have a high affinity for economic activities as demonstrated by FDI values in those cities more than other tier cities.

(c) The theoretically corrected network;

To find out which cities would have a great potential economically, the selection was on the cities in the 16 landlocked countries and port-cities in close proximity to the in-land cities. We then made connections between these cities to form an interlocking network between them and derived centrality scores for these cities.

The centrality measures all had an increase when the new connections were created by between 37% to about 88%, and several of them showed significance too on foreign investments attraction. In most instances, road infrastructure performance especially in Africa is measured by looking at dynamics of cost, condition, speed or safety. Infrastructure financing becomes a huge challenge. These results prove that a highly connected Africa has so much to gain, in agreement with a previous study by Redondi and Banno (2014) who introduced a new air route in Africa proving that this increased connectivity increases foreign investments into the continent. Good infrastructure connectivity must be in place for multinational corporations to set up their investments in any region.

Importantly, as we focus on inter-city connections, we cannot underestimate the importance of intra-city connectivity. A number of centralities at 30Km and 100Km radius were highly significant. To grasp the full extent of network centrality, more studies need to be carried out at local scales.
Based on network analysis techniques, which are the essential weak points in the network that can be developed in future to enhance greater connectivity in Africa?

The land-locked countries corridor and port-city-in-land city connections filled the gap of potential areas for infrastructure development. Regression results support that the utility of this improved network has an influence on the economic function of cities. The centrality scores significantly increased in the following cities, although at varying levels for different measures.

Table 9: Cities influenced by new connectivity

<table>
<thead>
<tr>
<th>Region</th>
<th>Western Africa</th>
<th>Region</th>
<th>Northern Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noadhibou</td>
<td>Tamale</td>
<td>Tangier</td>
<td>Ghadamis</td>
</tr>
<tr>
<td>Bamako</td>
<td>Ougadougou</td>
<td>Tarfaya</td>
<td>Algiers</td>
</tr>
<tr>
<td>Conakry</td>
<td>Niamey</td>
<td>Adrar</td>
<td>Murzaq</td>
</tr>
<tr>
<td>Abidjan</td>
<td>Port Harcourt</td>
<td>Hasi Messaoud</td>
<td>Port Said</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Laghouat</td>
<td>Tripoli</td>
</tr>
<tr>
<td>Region</td>
<td>South Africa</td>
<td>Region</td>
<td>Eastern Africa</td>
</tr>
<tr>
<td>Kolwezi</td>
<td>Maun</td>
<td>Mzuzu</td>
<td>Butare</td>
</tr>
<tr>
<td>Lusaka</td>
<td>Gaborone</td>
<td>Mbeya</td>
<td>Gitarama</td>
</tr>
<tr>
<td>Ondjiva</td>
<td>Kimberly</td>
<td>Dar-es Salaam</td>
<td>Entebbe</td>
</tr>
<tr>
<td>Walvis Bay</td>
<td>Cape-Town</td>
<td>Dodoma</td>
<td>Kampala</td>
</tr>
<tr>
<td>Lilongwe</td>
<td>Blantyre</td>
<td>Juba</td>
<td>Addis Ababa</td>
</tr>
<tr>
<td>Solwezi</td>
<td>Maun</td>
<td>Mombasa</td>
<td>Hargeysa</td>
</tr>
<tr>
<td>Bujumbura</td>
<td>Lira</td>
<td>Khartoum</td>
<td>Mogadishu</td>
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<tr>
<td>Bloemfontein</td>
<td>Bulawayo</td>
<td>Bujumbura</td>
<td>Lira</td>
</tr>
<tr>
<td>Pietermaritzburg</td>
<td>Zvishavane</td>
<td>Jima</td>
<td>Arusha</td>
</tr>
<tr>
<td>Durban</td>
<td>Harare</td>
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</tr>
<tr>
<td>Mbambane</td>
<td>Beira</td>
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<tr>
<td>Nampula</td>
<td>Nacala</td>
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<td></td>
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<tr>
<td>Region</td>
<td>Central Africa</td>
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<tr>
<td>N d’jamena</td>
<td>Kisangani</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maroua</td>
<td>Point-Noire</td>
<td></td>
<td></td>
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<td>Bangui</td>
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Connectivity between these cities increases their integration. As earlier stated, Africa is losing about 2% to 3% of its GDP due to low infrastructure development (AICD, 2015). An increased integration could significantly reduce this loss and potentially increase it through reduced travel costs for labour, reduced production costs for firms and increased market access.

To what extent do the network centrality measures influence attraction of FDI into the Manufacturing, Service, Hi-Tech and Resource sectors?

As seen manufacturing is the highest FDI sector. These is highly motivated by a need for affordable labour and efficient movement of goods from point of production to the market or consumption point. This is supported by the results of population, a proxy for labour availability showing robust positive results in most models. Reach was a constant significant factor in all the networks and in all sectors except for resource sector. Although Reach and Betweenness showed a negative relationship with the different sectors, Attraction Distance and Reach both had positive significant relationships in the sectors. On the Trans-Highways network, distribution of FDI was scanty. This was also supported by econometric analysis, as there was no significant centrality measure established for foreign investments. The most significant measures across all road networks were reach, betweenness and attraction distance.

5.3 Recommendations

Key stakeholders who have technically considered the reasons as to why Africa is the very least connected continent globally have identified a number of reasons for this; inadequate data, an absence of programs and plans, weak governance structures and corruption. The effects of an unconnected continent cannot be underestimated because this means locking Africa into a cyclic loop of low economic performance and poverty. Visionary and practical solutions need to be thought out and carefully implemented in order to break even. There is an identified huge financial gap required to cover the costs of infrastructure development (ICA, 2008). Inter-city collaborations can be a powerful way to help finance infrastructure development projects. Cities which stand to benefit from bridging their physical connectivity, can pull resources together to increase their bargaining power and reduce expenditure costs.

In addition to improving the potential for foreign investments and reducing trade costs, there are numerous opportunities that open up for a region once infrastructure connectivity is improved. Reduced cost of agricultural produce delivery, increased human movement between different points, capital flow, reduced travel costs and travel time, job creation amongst other advantages. The point brought forth is that if two or more cities/ countries would collaborate on their infrastructure development projects, instead of fragmented efforts, the impact this would have in facilitating a very cost-efficient method of filling the infrastructure gap. The combined benefits would outweigh the costs. Empirical evidence has shown how when some of the cities which are now fragmented and attract a certain level of foreign investments- when they are directly connected; up to 9.3% (model for the complete road network) increase in their potential to attract FDI. This has an effect too on expanding
the market access for economic activities and increasing the competitiveness of cities globally.

Foreign investments have been empirically known to bring positive benefits to a host country. We cannot underestimate that there are negative influences of FDI as well such as crowding out of local firms and increasing inequality. In light of this, it is time that African governments considered infrastructure-themed FDI and draw up strategies aimed at attracting firms that will create innovative technologies for the infrastructure sector. This can be a very effective way of financing their infrastructure projects. For instance, some technologies involve constructing roads from plastic waste materials, which foreign firms have the capacity to actualize. Smart governments would likely create a favourable environment through tax incentives and subsidies, access to resources in order to attract such bright technologies.

With the Trans African highways being improved, it is crucial to think of trans African railway lines. The African Union hopes to connect Port Harcourt in Senegal to Port in Djibouti, a project that would have very positive prospects in terms of job creation, reduced travel costs and time, improved trade activities and improvement of the citizens’ quality of life. Rail transportation is very crucial for moving goods and could help reduce traffic congestion, which is a major urban issue in many African cities. Rail transportation also paves way for adoption of renewable sources of energy such as electric-powered trains. Africa, which is still young in infrastructure development should take advantage of this and embrace technologies aimed at reducing carbon-footprint in view of achieving the sustainable development goals and AU Agenda 2060.

Economic communities, in a bid to increase their competitiveness for trade potential all have their plans and programs for infrastructure development. There is an importance of harmonizing all these plans across these bodies and also across different infrastructural projects. A comprehensive Infrastructure Development Plan for the whole continent is crucial if Africa has to achieve a unified economic growth. The Trans-African Highways master plan developed by the AU, AfDB and UNECA was such a brilliant and ambitious vision for the continent, however, lack of commitment and a poor implementation framework played a crucial role in their weak development.

Additionally, certain sectors of FDI are still lagging behind within the continent. Service and Hi-tech FDI attract very low values. Considering factors for FDI attraction, it is undisputed that infrastructure development is key. However, this is not limiting to road infrastructure single-handedly. ICT infrastructure is growing very high importance especially in this age where creativity and innovativeness is diving the economies. Service and Hi-tech sectors require advanced technological infrastructure. Therefore states should also ensure that infrastructure development is all-round but importantly harmonized in order to explore full potential in different regions.

It is important for the African governments to seriously consider cooperation amongst different governments in order to support transport development initiatives. This would really be a considerate move that would help to improve the management and financing of these projects and increased accountability. Transportation projects, no matter how long they take to pay off the investment money, eventually pay off. Innovative financing approaches such as; risk instruments and land value capture incentives (LVC) based on real estate development/ industrial zones and economic hubs on future transport corridors can be used as tools to reduce the financing gap.
Foreign investments have been established to benefit a country’s economy positively as reviewed in Chapter 2. However, several studies have also identified possible negative causes such as inequality, which further influences the social-economic development of regions. We have established in this research that increased road network centralities through new connections will increase foreign investments. In light of this, in order to leverage this effect so that there are minimal or no negative influences, we propose that states should develop comprehensive spatial development plans for the new corridors of connections. These plans should be supported with economic strategies that show a blueprint of how land use is distributed efficiently along these zones and the proposed productive activities that can enhance economic prosperity.

As new connections are developed, it is expected that this will reduce travel costs and time, open up several markets and urban areas, increase accessibility and positively increase the GDP of these areas. It is necessary that foresighted planning is done for these areas in order to prepare in advance for the anticipated changes. This ensures that these areas have the capacity; institutions, services and resources, required to spur continued economic growth.
The influence of road network centrality on FDI attraction in Africa

Bibliography


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## Annex 1: Description of Variables and Datasets

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Annex 2: Cities receiving foreign investments in Africa
Annex 3: Distribution of centralities across Trans Highways cities
The influence of road network centrality on FDI attraction in Africa

Annex 4: Spatial distribution of Total FDI, Population and Heat Maps of Attraction Reach and Distance

DISTRIBUTION OF TOTAL FDI

AFRICAN CITIES RECEIVING FDI WEIGHTED BY POPULATION SIZE

KERNEL DENSITY OF ATTRACTION REACH

KERNEL DENSITY OF ATTRACTION DISTANCE
Annex 5: Comparison of OLS and 2SLS Estimates- Current Road Network

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b = consistent under Ho and Ha; obtained from ivregress  
B = inconsistent under Ha, efficient under Ho; obtained from regress

Test: Ho: difference in coefficients not systematic

$$\chi^2(1) = (b-B)'[(V_{b-V_B})^{-1}](b-B)$$  
$$= 1.73$$  
Prob>chi2 = 0.1889  
(V_{b-V_B} is not positive definite)

Annex 6: Comparison of OLS and 2SLS estimates- Trans African Highways network

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b = consistent under Ho and Ha; obtained from ivregress  
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Test: Ho: difference in coefficients not systematic

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\( B = \) inconsistent under \( H_A \), efficient under \( H_0 \); obtained from regress

Test: \( H_0: \) difference in coefficients not systematic

\[
\text{chi2}(1) = (b-B)'(V_b-V_B)^{(-1)}(b-B)
\]

\[= 1.11\]

\[\text{Prob}>\text{chi2} = 0.2916\]

\((V_b-V_B\) is not positive definite)
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