SIMON DIEDONG DOMBO UNIVERSITY OF BUSINESS AND

INTEGRATED DEVELOPMENT STUDIES

LEVERAGING ON INFRASTRUCTURAL DEVELOPMENT TOWARDS INTERNATIONAL TRADE: EVIDENCE FROM SUB-SAHARAN AFRICA

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BY

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THESIS SUBMITTED TO THE DEPARTMENT OF BANKING AND FINANCE, SCHOOL OF BUSINESS, SIMON DIEDONG DOMBO UNIVERSITY OF BUSINESS AND INTEGRATED DEVELOPMENT STUDIES, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY IN FINANCE

OCTOBER, 2023

DECLARATION

Candidate

I hereby declare that this thesis is the result of my original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature:  Date: 18th October, 2023

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We hereby declare that the preparation and presentation of the thesis were supervised following the guidelines on supervision of thesis laid down by the Simon Diedong Dombo University of Business and Integrated Development Studies.

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DEDICATION

This thesis is dedicated to my Beloved MOTHER, Mrs. THERESAH ADOWA ADEDZEWAA ACKON, also known as AUNTE TAWIAH.

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LIST OF ACRONYMS

ACRONYM	MEANING
ARDL	Autoregressive Distributed lag
AfCFTA	African Continental Free Trade Area
AGR	Agriculture
AU	African Union
AVE	Average Variance Extracted
BCE	Before Christian Era
C	Control
CoC	Control of Corruption
CV	Co-efficient of Variation
DR Congo	Democratic Republic of Congo
ECOWAS	Economic Community of West Africa States
GDP	Gross Domestic Product
GoF	Goodness of Fit
EG	Economic Growth
EU	European Union
EX	Export
GCI	Global Competitive Index
GE	Government Effectiveness
Gov Exp	Government Expenditure
GFCF	Gross Fixed Capital Formation
GMM	Generalized Methods of Moments
H-O	Hecksher Ohlin

ICT	Information Communication Technology
Inf	Inflation
IF	Infrastructure Development
IM	Imports
IT	International Trade
LR	Likelihood Ratio
MANU	Manufacturing
Max	Maximum
MG	Mean Group
Obs	Observation
PD	Port Development
PLS-SEM	Partial Least Square Structural Equation Modelling
PMG	Pooled Mean Group
PoP	Population
PS	Political Stability
RGDP	Real Gross Domestic Product
RQ	Regulatory Quality
SER	Services
SSA	Sub-Saharan Africa
Std Dev	Standard Deviation
SVA	Sectorial Value Addition
TO	Trade Openness
UNCTAD	United Nations Centre for Trade and Development

US	United States
USD	United States Dollars
VIF	Variance Inflation Factor
WDI	World Development Indicators

ABSTRACT

Studies on infrastructure development and international trade abound in economic literature, both past and recent times, however, most studies focused on developed economies and those that studied Africa failed to delve into sub-Saharan Africa (SSA). This study re-examines the infrastructure development and international trade nexus in SSA by employing GMM, PMG, Hassen threshold estimator and PLS-SEM. The objective of the study is to examine how infrastructural development spurs international trade in SSA. Using 43 countries in SSA, with a panel data from 1985-2020 and a cross-sectional data for the year 2020, it was discovered that infrastructural development significantly promotes trade. Though the effects of port development on trade are highly significant, it depends largely on the measure of trade used but population however inhabits trade. Moreover, ICT positively impacted exports in the short and long run. Also, the service sector showed a positive impact in the short run through ICT, for export and a negative but highly significant impact through GFCF and port development for imports. With the threshold estimator, it revealed that GFCF on all the proxies of trade is U-shaped. That, it is economically prudent to operate below the threshold estimate for exports. Also, ICT and port development established a U-shape and an invented U-shape with export and import respectively. This means that depending on the objectives of the country, ICT, and port development spur trade. Regarding the mediating role, it was revealed that all institutional quality variables supported the hypothesis that institutional quality spurs international trade through infrastructure development in SSA. Therefore, it is recommended that emerging economies in SSA with a keen interest in improving trade must develop policies geared towards infrastructural development which has the potential of improving trade. Such policy(ies) could be a development plan which is aimed at improving infrastructure through digitalization, which all successive governments must be committed to. Furthermore, governments should prioritize developing the various sectors especially the service and agricultural sectors through ICT which spurs growth for developing economies.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

There is growing consensus among nations and supranational organisations on the advantages of large-scale networked infrastructure, such as roads, bridges, pipelines, energy grids, railroads, ports, airports, and zones devoted to commodities manufacture and transport. Moreover, in the present business climate, infrastructure-induced cost reductions have surpassed direct regulatory restrictions as a source of savings (Ochieng, Abala & Mbithi, 2020). The scientific research on economics and trade generally agrees that enhancements to physical and non- physical infrastructure may encourage trade between nations by reducing the cost of conducting business, which lowers the cost of production and improves competitive prices for exporting (Lendle et al., 2016).

Interestingly, the ability of a country to engage in international trade is influenced by numerous factors such as specific country legislation, trade tariffs, environmental factors such as waste disposal methods and most importantly infrastructure (World Bank, 2020b; World Trade Organization, 2018). These factors make international trade in sub-Sahara Africa difficult because of infrastructure deficit. The significance of infrastructure development for a range of economic outcomes, including commerce, cannot be overstated, and its impact on the exports and imports of the country is indisputable (Baita, 2021). This is because it improves accessibility and mobility and allows for more effective resource utilisation; infrastructure growth is essential for global trade (The World Bank, 2020b; World Trade Organisation, 2018).

On the other hand, trade between developed and developing nations increases because of more globalized and integrated markets (de Benedictis & Tajoli, 2011). International

trade promotes economic growth by securing comparative advantages and resource transfers (Kumari & Sharma, 2018). Consumer commodities like televisions and apparel, capital items like machines, basic supplies, and foods are often exchanged in developing economies like those in sub-Saharan Africa (Shan et al., 2014). Further, services are included in other transactions, such as payments for international patents and services pertaining to travelling (Lendle et al., 2016).

Furthermore, trade between countries has consistently contributed significantly to the rise in global wealth (Raychaudhuri & De, 2016). According to Stopford (2009) and the United Nations Centre for Trade and Development (2015), more than 80% of all trade occurs by sea nowadays. A high link exists between international trade, infrastructure, and GDP, as seen by the moderate 2.3% expansion in global merchandise trade volumes in 2014, which followed a 2.5% increase in the global gross domestic product (UNCTAD, 2015).

International trade is crucial to countries' growth and sustainability, as countries depend on one another. Based on this, economies join forces in commodity exchanges due to individual country's requirements and preferences (Bankole, Osei-Bryson, & Brown, 2015). This is where comparative advantage takes place among the countries involved. According to Karamuriro (2015), most African economies are characterised by low incomes, and trade is one of the essential channels required to promote structural reform and enhanced overall economic growth by ensuring exposure to larger markets, thereby increasing their economic growth, as evident in developing economies (Vo & Ellis, 2018). This is because trade enables countries to benefit from economies of scale by easing access to larger international market.

There is a wealth of literature on the connections between trade and infrastructure around the world. It often implies that international trade and infrastructure investments foster growth via the advantages of international trading, and that this linkage is strengthened by the favourable effects of infrastructure investments on international trade. The world's trade volumes have seen significant upheaval during the last 15 years especially in developed economies. Subsequently, trade growth has slowed dramatically in the global financial crisis, and apart from a brief recovery after the crisis, it has only barely recovered.

Globally, Rehnam (2020) showed that internet and ICT infrastructure greatly boost international trade. Additionally, Liu (2017) showed how the expansion of ICT has significantly aided the expansion of international trade. Moreover, Yang (2018) further noted that infrastructure in both developed and developing countries considerably aided in expanding both global trades.

Furthermore, it was found in Chang, Kaltani, & Loayza (2009) that the quality of an economy's infrastructure significantly influences how trade reforms would impact that economy. They further noted that trade openness positively correlates with GDP growth and adversely correlated with infrastructure quality. The relationship between several additional hard infrastructure (such as telephone lines and other ICT infrastructure, ports, and highways) and soft infrastructure (such as border and transit efficiency, as well as the business and regulatory environment) components and global trade flows has been extensively researched.

The desires of developing nations, especially those in sub-Saharan Africa, to achieve development through sustainable growth, the creation of jobs, the decrease of income disparity, and the alleviation of poverty is linked to their engagement with and

integration into the global economy in the context of trade globalization. The significance of ports in the global supply chain has expanded because of the globalization of sophisticated industrial production processes. The provision of logistical services in an international environment has evolved into a major component of port activities beyond only cargo handling (Wang & Cullinane, 2006). Making strong trade-related infrastructure, which comprises physical connection, an effective banking system, telecommunications, and high-quality energy infrastructure, is one of the finest approaches in this respect (Rehman, Noman, & Yibing 2020c). The least developed nations' inclusion in the global economy presents the chance and promise for rapid growth and the eradication of poverty (Portugal-Perez & Wilson, 2012). As a result, trade has received special attention as a legitimate avenue for economic interaction between nations. Orthodox international trade theorists acknowledge trade's positive effects and potential advantages for participating nations. From 2010 to 2016, Africa's USD-valued percentage of global commercial trade varied between 3.4% and 2.1%. This shows the downward performance of Africa in world trade.

Intra-African trade is essential for the continent's economic development and integration. With an average of 13% for imports and 17% for exports over the preceding seven years, intra-African commerce is still only a small share of overall imports as well as exports from Africa (World Bank, 2020). Even though the total value of exports decreased in 2016, when compared with 2010, the intra-export portion increased by 30%. It is said that trade restrictions and hurdles are to blame for the relative weakness of intra-African commerce. Interestingly, having access to a modern transport infrastructure is essential for a country's capacity to compete in the global market for goods, especially for developing nations. At this stage, a prominent subject for study is the causal connection between trade and infrastructure development. Although

significant infrastructure projects are continuously linked to increase trade competitiveness, the relationship between infrastructure and the expansion of international trade in sub-Saharan Africa is not well understood.

1.2 Problem Statement

The Economic Community of West African States (ECOWAS), the African Union (AU), and most recently the African Continental Free Trade Agreement (AfCFTA), to which most of the countries in sub-Saharan Africa have signed, are all known for developing and implementing numerous trade policies. Trade volumes in this region of the continent, however, continue to lag those in other parts of the globe (Rehaman et al., 2020).

International trade is crucial as nations work toward globalization and sustainable development objectives in this contemporary era. International trade enables nations to cooperate and exchange goods following their distinct needs and preferences (Bankole, Osei-Bryson, & Brown, 2015). There are several instances of significant infrastructure construction throughout history that was done to lower trade barriers. In terms of policy, the main goal of infrastructure development is to increase economic integration between the connected areas or nations and promote global trade. It is critical to assess the economic benefits of such big infrastructure investments since considerable taxpayer payments accompany them.

This study examines the effects of infrastructural development on international trade in sub-Saharan Africa, which, to the best of my knowledge, has been left unattended to in literature even though there are numerous trade agreements signed between countries in Africa, especially in sub-Saharan Africa. Nevertheless, there have been numerous studies on infrastructure-international trade nexus globally and in Africa. Even studies

conducted in Africa are concentrated in East Africa, North Africa, South Africa, and others to neglect of sub-Saharan African as a single unit of analysis.

Globally, the effect of infrastructure (road, airport, port, and telecommunications) quality on overall bilateral commerce as well as trade in the apparel, textile, and auto industries has been investigated (Yu, 2010; Zahonogo, 2016; Doku, Richardson & Essah, 2022). Furthermore, as port efficiency appears to have the greatest impact on trade on each of the infrastructure metrics, the standard of the infrastructure is crucial in determining how effectively trade performs. Finally, for the textile and automotive industries, timeliness and availability of telecommunication are substantially crucial for export competitiveness.

Additionally, Francois & Manchin (2013) examined a panel of international trade and the influence of the quality of institutions and infrastructure development on trade patterns using a Poisson estimator technique for multilateral resistance. They concluded that effective institutions are necessary for international trade, and exporters and importers must have access to a well-developed transportation and communications infrastructure. Additionally, while they place a focus on exports from developing nations, poor institutional and infrastructure quality also restricts exporters' access to markets. The data pattern suggests that policies that focus too much emphasis on developing countries' access to markets while offering insufficient support for trade facilitation may be ineffective.

Moreover, Donaldson (2018) examines the effects of India's train network using historical data from colonial India. He concluded that imperial India's railroads boosted regional and global trade. Furthermore, in contrast to Donaldson & Hornbeck (2016) and Donaldson (2018), who concentrate on historical train network expansions,

Charnoz et al. (2017) and Bernard et al. (2019) examine the recent introductions of high-speed rail and how this influences business results through increased face-to-face contact.

According to Ishikura (2020), a port or airport is also a necessary piece of infrastructure for international trade, as it is impossible to export or import for island nations without such a port infrastructure. Utilizing the explicit consideration of the asymmetric features of trade gateway regions within the context of the spatial computable general equilibrium model, he explained that infrastructural facilities in the international freight transport system also contain specific methods for handling and trading international goods in the "trade gateway" region. In his conclusion, he indicated that there is an imbalance in the transport or trade system between the trade gateway region and other locations.

Nevertheless, on the Africa continent, numerous studies have been conducted on the infrastructure-trade nexus. These studies include but not limited to Limão and Venable (2001); Ajakaiye & Ncube (2010); Bankole et al., (2015); Kodongo & Ojah (2016) Seck (2017); Yushi & Borojo (2019) among other studies.

To begin with, the impact of infrastructure on trade is examined by Celbis, Nijkamp & PootLow (2014) using estimates from 36 main research that produced 542 infrastructure elasticities of trade. They found that the impact of infrastructure depended on the location of the infrastructure. They also indicated that a 1% increase in domestic infrastructure would result in a 0.6 % increase in exports and a 0.3 % increase in imports. These elasticities are typically greater for macro-level assessments, land infrastructure, and developing nations or economies.

Further, using archived data from 28 African countries, the quality of institutions and information and communication infrastructure have a considerable beneficial impact on intra-African trade, according to research by Bankole et al. (2015) that looked at the effect of information and communication technology infrastructure on intra-African trade. Their findings suggest that good institutional quality and telecommunications infrastructure together improve effective intra-African trade flows.

A model of economic development boosted by an infrastructure variable is also estimated by Kodongo & Ojah (2016) using System GMM for panel data of 45 Sub-Saharan African countries for the period 2000-2011, considering Africa's glaring infrastructure deficit. They discovered that improvements in spending on infrastructure and access are among the elements impacting the growth and development of the economy in Sub-Saharan Africa. They also pointed out that the region's less developed countries are more affected by these significant correlations, particularly those concerning infrastructure spending, than are the comparably more developed ones, as they rarely are granted access to greater infrastructure than almost none.

Seck (2017) uses a range of trade facilitation measures, such as border effectiveness, physical infrastructure, regulatory bod

ies, the environment, information and communication technologies, and logistics performance for 2007-2012, to investigate how various elements of the sub-Saharan African trade cost landscape could have contributed to trade patterns both within the continent and with the rest of the world.

In their analysis of 44 African nations and their 173 trading partners between 2000-2014, Yushi & Borojo (2019) look at the effects of institutional quality, border and transportation efficiency, physical infrastructure, and communication infrastructure on

both intra-African and international trade. The results show that the standard of institutions strongly influences trade within Africa and throughout all of Africa, the effectiveness of borders and transportation, and the physical and communication infrastructure. The study found a marginal relationship between GDP per capita and the amount of physical and communication infrastructure, institutional quality, and trade flow. The marginal impacts of borders and transportation efficiency result in a decline in GDP per capita. The above literature examined the effects of infrastructure on trade flows between various countries.

However, the studies that have been done thus far are limited in scope and contain methodological deficiencies. This includes but not limited to the following; the use Ordinary Least Square (OLS) methods which mostly fails to correct endogneity issues and the use of single country approach. Additionally, this study is distinct from earlier studies in several aspects. First and foremost, after reviewing the literature, this is the first study that examines infrastructure-trade nexus in sub-Saharan Africa using variables for both "soft" (ICT Adoption) and "hard" (Port Development and Gross Fixed Capital Formation) infrastructure as previous studies used only one of them to measure infrastructure. Furthermore, this paper adds something unique regarding its methodology (empirical model). The study uses the system generalized method of moments (GMM) dynamic pooling estimator created by Arellano and Bond (1991) and Arellano and Bover (1995) which corrects the econometric issues of endogeneity of the lagged dependent as well as the unobserved country-specific effects common in panel estimations of this kind, as opposed to the traditional co-integration and ordinary least squares (OLS) estimations which were used in some of the previous studies. Pooled Mean Group employed to explore the short and long-run effects because it generates reliable and effective long-run estimates. Hassen (2000) sampling splitting approach to

estimate the threshold effects and finally uses Partial Least Squares Structural Equation Modelling (PLS-SEM) to examine the mediating role of institutional quality. These methodologies make the study unique and distinct from previous studies.

1.3 Research Objectives

The general research objective of the study is to examine the effects of infrastructure development on international trade in sub-Saharan Africa.

Specifically, the study seeks to achieve the following objectives:

1. To examine the effects of infrastructural development on international trade in sub-Saharan Africa.
2. To explore the transmission channels through which infrastructural development affects international trade in sub-Saharan Africa in the short and long run.
3. To determine whether the effects of infrastructural development on international trade in sub-Saharan Africa is threshold specific.
4. To explore the role of institutional quality in infrastructural development and international trade in sub-Saharan Africa.

1.4 Research Questions

The general research question of the study is: what are the effects of infrastructural development on international trade in sub-Saharan Africa?

Specifically, the study intends to ask the following questions.

1. What are the effects of infrastructural development on international trade in sub-Saharan Africa?

2. What are the transmission channels through which infrastructural development affects international trade in sub-Saharan Africa in the short and long run?
3. Are the effects of infrastructural development on international trade in sub-Saharan Africa threshold specific?
4. What is the role of institutional quality in infrastructural development and international trade in sub-Saharan Africa?

1.5 Significance of the study

This study investigates an important topic in sub-Saharan Africa, Africa, and the globe. It examines the effects of infrastructural development on international trade considering the numerous trade agreements that have existed in this part of the globe, but limited or no benefits are derived from them. Infrastructural development is known as the catalyst for promoting international trade in developed economies, highlighting the need for developed infrastructure, especially when trade is in the picture.

This study is crucial because it demonstrates how the growth of sub-Saharan Africa's infrastructure has fuelled global trade. The importance of this research can be divided into two (2) categories, which contribute to its significance at a policy level with respect to its implications for the economies of sub-Saharan Africa and literature.

In contributing to the literature, this study adds to existing scanty literature on international trade and infrastructural development nexus, especially in sub-Saharan Africa. Literatures on infrastructure development and international trade nexus are mostly country-specific, and as such, this study, which involves countries in sub-Saharan Africa and covers forty-three (43) countries, will provide an in-depth understanding and effects on the infrastructure-international trade nexus. Also, this study adds to the literatures on the determinants of international trade, especially in

developing economies. Previous studies on trade citied financial development, economic growth, and exchange rate volatility, among others, as some of the determinants of international trade, specifically in Africa. Nevertheless, this study includes infrastructural development as another determinant of trade in sub-Saharan Africa. This study, therefore, adds up to the trade literature. Also, the methodological approaches used is seen as an "eye opener" in the infrastructure-trade nexus.

Aside the study being of great significance in literature, it is also significant in policy implications. This is where the study findings will help various governments, institutions, and the public in sub-Saharan Africa understand the crucial role of infrastructural development in promoting international trade in sub-Saharan Africa. Moreover, the study is significant because it uncovered the exact effects of infrastructure development and international trade and proffer solutions to it. For instance, the threshold estimation indicates the regime that countries in sub-Saharan Africa needs to operate to maximize trade policies established through infrastructure development. Further, results from the role of institutional quality will inform policy makers in sub-Saharan Africa on the need to practice government effectiveness, control corruption, political stability, and regulatory quality, among others, to achieve a positive relationship between infrastructural development and international trade.

1.6 Scope of the study

This study covers 43 countries in sub-Saharan Africa including Angola, Benin, Botswana, Cape Verde, Central African Republic, Equatorial Guinea, Ghana, Kenya, Lesotho, Madagasca, Namibia, Rwanda, Seychelles, Tanzania, Uganda, Zimbabwe among others. Also, the data used for the study spanned from 19985 to 2020. The study looked at the variables of infrastructure development (ICT Adoption, Port Development and Gross Fixed Capital Formation), measures of international trade (Import, export

and Trade Openness), among other variables of interest such as institutional quality (Control of Corruption, Government Effectiveness, Political Stability and Regulatory Quality), Real Gross Domestic Product, Population, Inflation among others. Further, the study employed the use of data which spans from 1985-2020, that is a period of 36 years.

1.7 Organization of the study

The thesis is divided into five major parts; the contents of each chapter are detailed below. A short history of the infrastructure-trade nexus is provided in Chapter 1 as an introduction to the research or study. By specifically articulating the research gap to be filled, the research questions, the research aims, as well as the importance and scope of the study, it also draws attention to the statement of the problem. The theoretical and empirical literature on international trade nexus, infrastructural development nexus, and stylized data on trade in sub-Saharan Africa and Africa in general are all examined in detail to better understand the issues at hand and are captured in Chapter 2 of this study. The relationship between infrastructure development and global trade and its effects on the latter were given specific and highly consideration. The research's methodology is described in depth in Chapter 3. It covers, among other things, the study's scope, data and data sources, measurements of the variables, and model estimation where the estimation approach is done following each objective stated in the study. The research results are examined and discussed in depth in chapter 4. This is carried out following each of the study's objectives, where the preliminary findings of each objective which is made up of the descriptive statistics and correlation coefficients are not left out in addition to the findings and discussions. In chapter 5, the study details the key findings uncovered in the study, the conclusion and recommendations to suggest policies targeted at improving trade volume and obtaining the intended benefits of the numerous

trade agreements that have existed since time in memorial in this part of the continent or globe.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section of the study details the review of related literature on infrastructure-trade nexus. This chapter is categorised into four main sections, namely, a description of concepts on the two most important variables in the study: infrastructure and international trade, stylized facts on infrastructure and international trade, theoretical framework or foundation and empirical literature establishing the infrastructure-trade nexus by previous scholars in the world of finance.

2.2 Definition of Concepts

In this section, the study will detail the meaning and assumptions of the two variables adopted in the study. Here, the study details all the components of infrastructure and international trade, considering their types, importance, and weakness, among others.

2.2.1 The concept of Infrastructure

In the late 1880s, the term "infrastructure" first appeared in English. Infra, which means underneath and may be used to denote "foundation," and structure, which refers to a building, are its French etymologies. Infrastructure is the foundation upon which a nation's economy is built. This raises the issue of infrastructure's significance for achieving economic development in every economy and nation, both developed and developing economies as well.

Therefore, infrastructure is referred to as the underlying physical foundation of an organisation, region, or nation, according to United Nations Centre for Trade and Development (2015). It often involves industrial activity or the production of public

goods. Examples include the infrastructure for sewage, water, communications, and education. Infrastructure projects are essential to a region's growth and prosperity, even though they can occasionally be expensive and capital-intensive. There are many ways to finance infrastructure improvement projects, including public, private, or partnership arrangements. The term "infrastructure" also covers a wide range of structures and systems that require physical support, such as the electrical grid that spans an entire city, state, or nation. In addition to supplying citizens with necessities like food and water and enabling them to engage in the social and economic community, infrastructure also includes buildings, machinery, or other physical assets like bridges and roads that are essential to a nation's economy (Lendle et al., 2016). Private contributions may assist in upgrading certain public infrastructure. For instance, someone could donate money to the area's hospitals, schools, or police enforcement.

In addition, Tinbergen (1962) proposes the difference between superstructure (which comprises industrial, agricultural, and mining enterprises) and infrastructure (which includes things like roads, hospitals, and education). Theoretically sources for these ideas as well as specific definitions of them cannot be determined in this context. According to him, "Infrastructure is defined as the sum of the material, institutional, and personal facilities and data that are available to the economic agents, and which contribute to realising the equalisation of the remuneration of comparable inputs in the case of a suitable allocation of resources, that is complete integration and maximum level of economic activities" (Jochimsen, 1966, p. 100).

2.2.2 Types of Infrastructure

In the realm of literature, two words are often used to denote different kinds of infrastructure. Both physical and soft infrastructure fall under this category. Infrastructure is typically broken into several hard and soft components. As opposed to

the services needed to meet a population's social, economic, and health demands, soft infrastructure is described as the real, physical construction of infrastructure like roads, bridges, tunnels, and trains (Shan et al., 2014).

2.2.2.1 Hard Infrastructure

A physical infrastructure is necessary for the operation of a contemporary, industrialised nation. A few examples include roads, highways, bridges, and machinery required to run them, including transits buses, cars, and oil refineries. To support business operations, hard infrastructure contains technical elements like networking hardware and cabling (UNCTAD, 2015). The Brookings Institutes estimates that 14 million people work in industries that depend heavily on infrastructure. From locomotive engineers and electrical power line installers to truck drivers and construction workers, the infrastructure sector employs more than 11% of all workers in a nation.

2.2.2.2 Soft Infrastructure

Another kind of infrastructure is the soft infrastructure. The phrase "soft infrastructure" refers to the intangible components of infrastructure, including the institutions and human capital, needed to support an economy that offers the population specialised services like healthcare, banking, security, job creation and security, and education, among others. Additionally, investments in soft infrastructure seek to raise people's living standards, involvement in everyday activities, and quality of life (see Ochieng, Abala & Mbithi, 2020). Technology acceptance and use are the most known examples of soft infrastructure.

2.2.3 The Concept of Trade

Trade is the act of transferring products and services from one person or institution to another, frequently in exchange for cash (Ochieng, Abala & Mbithi, 2020). Bartering, or exchanging products and services directly for other commodities and services, was an early type of trade that took place before the invention of money. However,

nowadays, most trade agreements are reached using a medium of exchange, like money or any legal tender. As a result, selling or earning can be distinguished from buying. Since the inception of money, along with the development of paper money, non-physical money, and letters of credit, tremendously facilitated and encouraged trade (Sare et al., 2018). Trade exists between regions because they may each have a comparative advantage (actual or imagined) in producing various commodities that may be traded, including the production of natural resources that are otherwise scarce or in limited supply (Sare, 2019). For instance, the size of certain locations may promote mass production. Trading at market rates between places can be advantageous in such situations for both locations. Bilateral trade is trade between two traders, whereas multilateral trade is trade involving more than two dealers.

Historically, from 1815 to the start of World War I in 1914, some areas' openness to free trade significantly improved. The 1920s saw a rise in trade once more, but the 1930s saw a fall (particularly in Europe and North America). From the 1950s onward, trade significantly rose once more (although with a halt during the 1970s oil crisis). However, the first step towards trade in the past was personal contact. Prior to the development of modern money, prehistoric people mostly exchanged services and products with one another in a gift economy by trading. Furthermore, Homo sapiens, who mostly used the Danube River, made the first contact between Mediterranean cultures between 35,000 and 30,000 BP. Some claim that the first transactions in primitive times are where trade first began. For prehistoric humans, bartering what they had for one another's goods and services supplanted conventional self-sufficiency as the main method of subsistence. In most of documented human history, trade is thought to have existed. There is proof that obsidian and flint were traded during the Stone Age. From 17,000 BCE onward, obsidian trade is thought to have existed in New Guinea.

2.2.3.1 Types of Trade

There are numerous trade different types of trade available around the globe, however, the most common ones are export, import, and entrepot. A detailed explanation of the various types is done below.

2.2.3.1.1 Export

This is one form of trade. Export as a form of trade is when products are exported, they are transported from their place of origin to another or a foreign country. Additionally, export commerce takes place when people from other nations purchase goods produced in another. Services provided in one country to a citizen of another country may also fall under this category. The side selling the products or services in this transaction is the exporter. Most of the products we export from the United Kingdom include cars, jet engines, drugs, gold, and crude oil. For instance, according to United Nations Centre for Trade and Development (2022), British exports in June 2021 were £51.2 billion. This shows the crucial role that exports trading occupies in international trade in the world.

2.2.3.1.2 Import

Any item or service that is acquired outside of the country of origin is considered an import. Imports and exports make up international trade. Every nation may be unable to generate all the commodities they need at a particular period, so they are obliged to outsource such commodities that they do not have control over. In addition, this is the process of transporting goods or services from the country where they were first produced or generated into another country for consumption. A product is often imported if there is no market for it in the country of origin or it has over-grown its market in the foreign country. Alternatively, if a nation's production costs are much lower than they would be in the nation from which the items would be imported. Crude

oil is an example of a product that may be imported if it cannot be produced in the target country. Additionally, if a nation's imports are greater than its exports, it has a negative trade balance, or a trade deficit (UNCTAD, 2015; UNCTAD, 2022).

2.2.3.1.3 Entrepot

The practise of importing goods into a country, having them distributed there, and then having them sent back out again is known as entrepot trade, sometimes known as transhipment. If metal is imported from Nigeria to Ghana, processed, and then exported back to Zimbabwe, it is entrepot trade. This form of trade is employed for a variety of purposes, such as gaining access to machinery, improving technology, and strengthening international ties (Fertö, 2009). Most wealthy nations, including the United States of America, the United Kingdom, and China, engage in this kind of international trade.

2.3 Stylized facts on trade in sub-Saharan Africa

Trade is crucial to countries and without it no country can literally exist. On the African continent, 49 nations make up Sub-Saharan Africa, which is currently integrating into the largest free trade zone in the world (Donaubauer et al., 2018). With a combined market population of over 1 billion people and a GDP of more than $1.5 trillion, sub-Saharan Africa offers significant opportunities for foreign enterprises. Given that sub-Saharan Africa is home to some of the fastest-growing economies in the world, rapid population and GDP growth will only broaden this potential in the future (Francois and Manchin, 2013). This indicates the potential of sub-Saharan Africa concerning trade. For instance, in 2019, more than $38 billion in goods and services were exchanged between the United States and sub-Saharan Africa, including more than $15 billion in exports. The $238 billion in imports from Sub-Saharan Africa in 2019 highlights the

potential for the American market share to increase. However, available data shows this potential has not been realized or achieved. Using data from World Development Indicators and spanning from 1985-2022, the study constructed a 5-year average of trade volumes in sub-Saharan Africa which spell out their contribution to the world trade. Table 2.1 details the findings from the 5-year averages using import and exports data.

Table 2. 1: 5-year average trade volumes in sub-Saharan Africa (1985-2022)

Variable	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019	2020-2022
Import	25.208	26.779	30.528	34.082	41.107	42.575	39.262	27.451
Export	19.072	19.115	22.537	26.805	31.528	31.713	28.091	19.767

Source: Author's construct (2023).

Note: Data from World Development Indicators

The table above (2.1) revealed that from 1985-2022, average import has always been higher than exports over the period. This is unsurprising as countries in sub-Saharan Africa experience a deficit balance of payment. Regarding the volume of imports over the period, it was uncovered that there was an increase in importation of goods and services in sub-Saharan Africa from 1985 to 2014. During this period, imports in sub-Saharan Africa increased at an increasing rate. However, it reduced from 2015-2022. This means that, the over-reliance on import reduced during this period. This could be because, within this period, countries in sub-Saharan Africa have been able to produce chuck of the goods needed for use by citizens. It is the hope and aspirations of most countries to be able to export more in relation to their imports for good economic growth but in sub-Saharan Africa, exports are just a fraction of the overall gross

domestic product. From 1985 to 2014, there was increased over the period which was seen as progress, and this could be because more production capacity in these countries increased making it possible to export some. However, exports reduced marginally from 2015 to 2019 and drastically from 2020 to 2022 period and it was due to the emergence of Covid-19 pandemic, which affected production around the globe and it's not surprising countries in sub-Saharan experience decrease in export. In the nutshell, it can be seen in the table above that, there is a positive relationship between import and exports in sub-Saharan Africa. This is because, as import increases in sub-Saharan Africa, export also increases as well.

Regarding the trend of import and export, a graph has been established (see figure 2.1) below to depict the import and export trends in sub-Saharan Africa. This is a graphical representation of the table above to give a pictorial view of the import and export situation in sub-Saharan Africa.

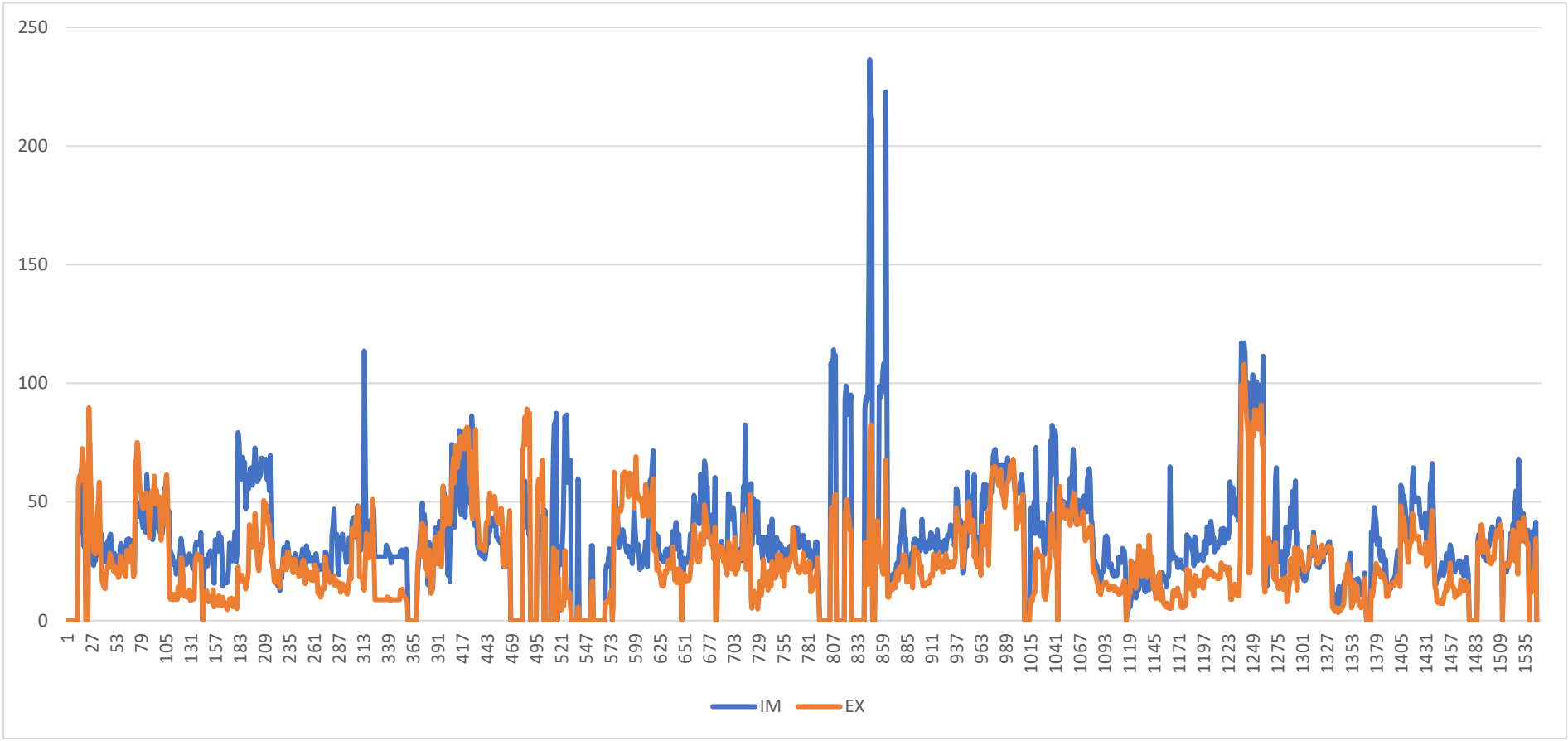

Figure 2. 1: Import and Export in sub-Saharan Africa spanning from 1985-2022

Source: Author's Construct (2023).

Moreover, aside from infrastructure, there is another factor that determines the trade volumes in sub-Saharan Africa and the world as a whole: trade openness. In sub-Saharan Africa, trade openness has been volatile over the period. This unstable or volatile nature could be attributed to numerous factors such as trade barriers and laws. The figure below (Figure 2.2) shows a graphical representation of it.

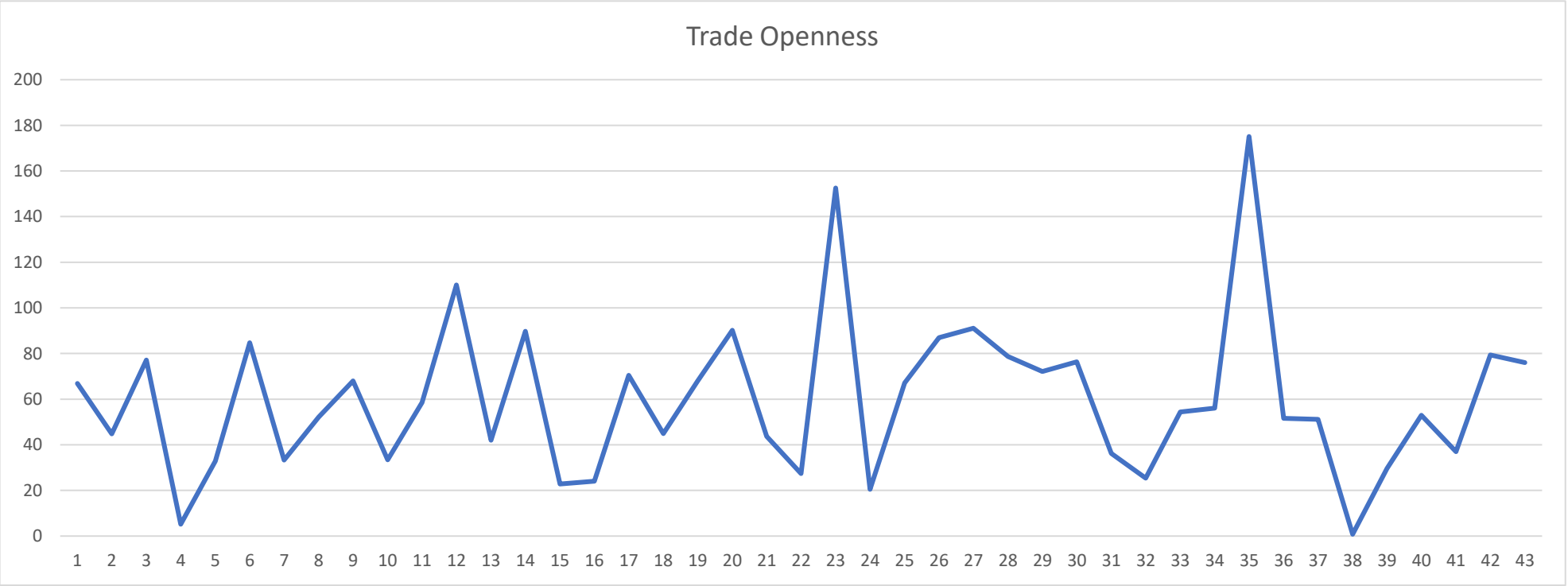

Figure 2. 2: Trade Openness in sub-Saharan Africa from 1985-2022

Source: Author's Construct (2023).

2.4 Theoretical Foundation

In conducting the study, the study relied on theories on the two essential variables of the study. Theories on infrastructure development and theories on trade. Some of the theories include but are not limited to the following: infrastructure-led development theory, H-O theory, theory of comparative cost advantage, absolute cost advantage theory among others.

2.4.1 Theoretical framework: Infrastructure-led Development (Agenor, 2010)

The study adopted Agenor (2010) infrastructure-led development theory to examine the infrastructure trade nexus. In this theory, infrastructure is seen as the engine of growth of countries or economies and such as countries' economies will experience low economic growth due to low infrastructure development. This is where various governments invest in infrastructure such as roads, ICT development, port expansion and development, which in turn increases productivity. This idea goes on to claim that infrastructure has an impact on the creation of goods, improving commerce over time. Infrastructure efficiency is not linear because of network effects. However, if governance is sufficient to ensure that there is a sufficient degree of efficiency of public investment, then an increase in infrastructure spending may help to facilitate the movement from the low-growth equilibrium, which has been defined by inadequate productivity and insufficient savings through trade, to a high growth equilibrium. This makes infrastructure a crucial element of development, particularly in emerging nations like those in sub-Saharan Africa, and one that merits research since trade is essential to progress. This therefore underscore the need for the adoption of this theory.

2.4.2 Hecksher Ohlin Theory (H-O Theory)

Smith and Ricardo's thesis prevented nations from deciding which goods would bring them greater profits. In the 1900s, Eli Hecksher and Bertil Ohlin, two economists, were fascinated with the issue of how a nation may develop riches by producing commodities using resources that were abundant in the country. They discovered that materials with a high demand in relation to supply would be more expensive, whereas materials with a small demand in relation to supply would be less so. The General Equilibrium and Modern theories are other names for the H-0 theories. According to this theory, factor endowment and factor pricing were the major factors affecting global trade. The Factor Price Equalisation and H-0 Theorem are the two theorems that make up the H-0. The factor-price equalisation theorem deals with how global trade affects factor prices, whereas the H-0 theory forecasts the pattern of trade. Two more subcategories of the H-0 hypothesis are factor intensity and factor abundance. Physical units and relative factor pricing can be used to explain factor abundance. Capital and labour are measured in physical units, whereas adjacent expenses like rent, labour costs, etc. are involved in relative factor pricing. On the other hand, factor intensity describes the number of resources a nation has, such as capital, labour, technology, etc. Here is where infrastructure development comes into play. The adoption of ICT, which substitutes technology in this theory, as well as capital investments, the research employed port development and gross fixed capital formation were used as proxy measures for infrastructure development in this study. As a result, this theory is most appropriate for the research since it describes how variables like infrastructure development impact trade within and across nations, particularly in sub-Saharan Africa.

2.4.3 Theorem of Absolute Cost Advantage

The founder of modern economics, Adam Smith, developed this theory. The mercantilist and protectionist theories of global commerce were rejected in favour of this one. Adam Smith believed free trade was essential since it was the only guarantee of increased trade. According to his argument, a nation should only create goods with a clear competitive edge. According to Smith, free trade contributed to the growth of the global market. Producers with distinct absolute advantages can always outperform producers in other locations through specialisation and the division of labour. He placed much emphasis on a nation's ability to create more at less expense than other nations. This theory contends that a nation should export goods when it can do so at a reduced cost since doing so will help to lower the price that will ultimately be placed on them, making them more affordable for consumers in other countries.

2.4.4 Comparative Cost Advantage Theory

David Ricardo was the one who originally proposed the idea of comparative costs. Later, J. S. Mill, Marshall, Taussig, and others enhanced it. Absolute advantage is not necessary, according to Ricardo. According to him, a country will produce where it has a comparative advantage. According to the theory, each nation should concentrate on producing the goods in which it has the most advantages or the least disadvantage. Therefore, a state would import the goods from which it loses the least and export those from which it gets the most. When a nation has sufficient assets to produce a good more expertly than it does other items, it has a comparative edge over other nations.

2.5 Empirical Literature

This section of the study considers the various research done on infrastructure development and international trade. This section specifically investigates the

relationship existing between infrastructure development and international trade as established by numerous authors who attempted to wade into the controversial debate.

Evidence from earlier studies offered by Bougheas et al. (1999) relating to infrastructure and transportation costs and subsequently on international trade using the gravity model and uncovered that, infrastructure offered negative impact with transportation cost and subsequently improving trade. Moreover, the effect of infrastructure on international trade is also supported by the available research. Infrastructure has a significant quantitative role in influencing overall transport costs, as shown by Lima˜o & Venables (2001). They revealed that in coastal areas, bad infrastructure accounts for 40% of expected transport costs and in landlocked ones, up to 60%. Also, Grigoriou (2007) re-visited the landlocked-trade argument using data from 167 countries concluded that improving roads within a landlocked country might not be enough to boost trade if other factors, such as transit country infrastructure, bargaining power with transit countries, and transportation costs, also weigh heavily. Similarly, Nords et al. (2006) used cross-sectional data for 140 countries in 2004 to examine the impact of time for exports and imports on international trade. They found that delays cause decreased trade volumes and make businesses less likely to enter export markets for time-sensitive products. For 22 EU member states, Persson (2008) employs a sample selection method to evaluate the possible impacts of trade facilitation in the form of the time needed to export and import on trade flow. According to the findings, trade flows are drastically reduced when both the exporter and the importer experience delays in processing times. Additionally, the data shows that a one-day decrease in border delays in the exporting nation, relative to the sample mean, would increase exports by around 1%.

Still on the gravity model, Anderson & Marcouiller (2002) further discovered that the institutional quality of the trading countries favours the amount of bilateral trade. Further in the literature De Groot et al. (2004), Institutional quality and governance quality are shown to have a strong, positive, and significant effect on bilateral trade flows. Moreover, ports, customs, regulations, and e-business were taken into consideration by Wilson et al. (2004) when quantifying the effects of trade facilitation. These sectors are crucial for all types of trade. The benefits of unilateral trade facilitation policies, according to the authors, are highly substantial and fall disproportionately on exporters and four aspects of trade facilitation are assessed.

One element of institutions that Ranjan et al. (2005) examined in their study is the effect of contract enforcement on international trade. They develop a theoretical model to demonstrate how weak contract enforcement might decrease the flow of commodities for which quality matters. They used a gravity equation with proxy measures of contract enforcement and uncovered that these metrics have an impact on trade volumes for both specialised and standard products. Furthermore, Depken & Sonora (2005), who also use a gravity model. They conclude that more exports from the United States to a partner nation is associated with that country's higher institutional quality. Besides institutional quality, the relevance of high-quality physical infrastructure to international trade is emphasised by Burn et al. (2005) and they concluded that, especially in developing economies, tends to improve trade for that country.

Notwithstanding, Levchenko (2007) finds that institutional variations among nations are key predictors of trade patterns and suggests that differences in institutional quality might be a source of competitive advantage. Helble et al. (2007) investigated how their level of institutional openness affects Asia-Pacific nations' trade. They concluded that trade costs are significantly influenced by the degree to which the trading environment

is open, predictable, and streamlined. For sectors where investments based on relationships are crucial. Moreover, Abe & Wilson (2008) use a computational general equilibrium model to investigate whether more openness to trade and less corruption may reduce trade costs in the Asia-Pacific Economic Cooperation area. Their research suggests that increased openness and less corruption positively affect regional trade and economic growth. Njinkeu et al. (2008), authors of another research on intra-African trade, found that strengthening port and services infrastructure seems to be more effective than other approaches in boosting trade in this area, and Iwanow and Kirkpatrick (2008) examine the influence of trade facilitation and infrastructure on exports in Africa and find a favourable relationship between the two. Similarly, Sonora (2008) uses a gravity model to evaluate the impact of economic freedom on US consumer exports and imports for the years 2000 and 2005, and he finds that more economic freedom in the partner nation increases U.S. exports. Therefore, in addition to the conventional drivers of trade flow, the business climate, infrastructure, and institutional quality should be taken into consideration in any empirical evaluation of the consequences of non-tariff barriers to trade flow.

Furthermore, Iwanow & Kirkpatrick (2009) use a panel dataset of 124 developed and developing nations from 2003-2004 to analyse trade facilitation, or the reduction of transaction costs associated with the enforcement, regulation, and administration of trade policy. Their findings suggest that removing institutional barriers to trade and manufacturing exports in Africa is a viable strategy for boosting the continent's export performance. In addition, Chang, Kaltani & Loayza (2009) discovered that the standard of an economy's infrastructure greatly affects the effect of trade liberalisation on that economy. They also found that freer trade was associated with higher GDP growth but a worse grade of infrastructure. Other components of both physical (such as telephone

lines and other ICT infrastructure, ports, and roads) and soft (such as border and transit efficiency, as well as the business and regulatory environment) infrastructure have been researched concerning international trade flows.

Moreover, the impact of delays in international trade for 146 countries in 2005 is also analysed by Djankovet al. (2010) using the gravity equation. According to their research, the average trade deficit is at least 1% every day a product is delayed before shipment. Yu (2010) uses a theoretical framework to estimate a gravity model that includes a measure of democracy, and he finds that democratisation greatly boosts commerce, maybe contributing by 3-4% overall to bilateral trade growth. The effects of "soft" and "hard" infrastructure on export performance in developing nations are investigated by Portugal-Perez and Wilson (2012). Their findings support the idea that export performance may benefit from the use of trade facilitation measures. In addition, Francois & Manchin (2013) analysed the effect of institutional quality and infrastructure development on trade patterns using a panel of bilateral trade data and a Poisson estimator expanded with the Baier & Berstrand (2009) technique for multilateral resistance. They arrived at the following conclusion: exporters and importers need a developed transport and communications infrastructure, and efficient institutions are crucial for international commerce. While these countries prioritise exporting, their weak institutional and infrastructural systems make it difficult for their exporters to reach consumers.

Notwithstanding, Celbis, Nijkamp & PootLow (2014) analyse the effect of infrastructure on trade by estimating 36 primary studies' worth of research to develop 542 infrastructure elasticities of trade. They concluded that the influence of infrastructure varied with its location. Exports were predicted to rise by 0.6% and imports by 0.3% for every 1% improvement in domestic infrastructure. Macro-level

evaluations, land-based infrastructure, and economies under development often have higher elasticities. Furthermore, Bankole et al. (2015) examined the impact of ICT infrastructure on intra-African trade using historical data from 28 African countries and found that both institutional quality and ICT infrastructure significantly boost intra-African trade. Their research shows that high-quality institutions and advanced communication networks contribute to intra-African trade's success. Individual measures of physical and soft infrastructure's impact on Asian nations' trade performance are analysed by Ismail & Mahyideen (2015), however, this study was conducted in Asia. In this analysis, they quantify the effects of hard and soft infrastructure on export and import volumes and many economic development measures in the area. The findings show that increased trade between Asian nations is a direct outcome of investments in all modes of transportation infrastructure, including roads, airports, railroads, seaports, and inland ports. Their findings strongly support the effects of soft infrastructure on trade flows. Some empirical research has underlined the significance of information and communication infrastructure. In addition, Kodongo & Ojah (2016) use System GMM to estimate, for a panel of 45 Sub-Saharan African countries for the period 2000-2011, a model of economic growth boosted by an infrastructure variable. This is done because of Africa's glaring lack of infrastructure. They found that increased expenditure on and access to infrastructure are major determinants in Sub-Saharan Africa's economic growth and development. More developed countries in the area seldom have access to greater infrastructure than absolutely none, therefore these researchers concluded that the significant relationships, especially those connected to infrastructure expenditure, are more meaningful for the developing countries in the region.

Additionally, Seck (2017) uses several trade facilitation measures, including border efficiency, physical infrastructure, regulatory environment, ICT, and logistics performance for 2007-2012, to examine how the composition of the sub-Saharan African trade cost landscape may have affected trade patterns both within and outside the region. In addition, Donaldson & Hornbeck (2016) and Donaldson (2018), which focus on historical expansions of train networks, contrast with Charnoz et al. (2017) and Bernard et al. (2019), which analyse the recent introductions of high-speed rail and how this influences business results through more face-to-face contact. Moreover, Donaldson (2018) uses colonial-era data to analyse the influence of India's railroad system. One of his findings is that the railways built by the Indian Empire facilitated more regional and international trade. Further, institutional quality, border and transportation efficiency, and physical and communication infrastructure were examined by Yushi & Borojo (2019) in their analysis of international and intra-African commerce between 44 African countries and their 173 trading partners from 2000 to 2014. The findings demonstrate that the quality of institutions significantly impacts trade within and across Africa, the efficiency of borders and transportation, and the strength of physical and communication infrastructure. The research finds that institutional quality and physical and communication infrastructure availability tend to have a rising marginal impact on trade flow as GDP per capita increases. Insignificant improvements in border and transportation efficiency have a negative impact on GDP per capita. Finally, Rehnam (2020) shown that worldwide internet and ICT infrastructure significantly increase global trade. As Liu (2017) further shown, the development of ICT has greatly facilitated the growth of international commerce. Also, Yang (2018) said that improving infrastructure in both developed and developing nations was a major factor in the growth of international trade. To add to, Ochieng et

al. (2020) estimated infrastructure development, institutions and intra-regional trade I East Africa and concluded that, infrastructural development through instutuions improves trade in East Africa. Finally, using the spatial CGE model approach, Ishikura (2020) investigated the regiona economic effects of transport infrastructure development on international trade and uncovered that developed infrastructure is the gateway to improve international trade in developing economies.

2.6 Conclusion

In a nutshell, it can be deduced that the literature on infrastructure development and international trade are numerous, however, some literature gaps were uncovered in all the studies. It was seen that; international trade is crucial to countries around the globe and the survival of such economies rest on how the various countries interact with one other through trade deals. It was uncovered that most of the studies were conducted in developed countries and the few that were conducted in developing economies such as those in Africa concentrated on East Africa, North Africa among others, to the neglect of sub-Saharan Africa. Furthermore, the mediating role of institutional quality has been extensively researched but not in sub-Saharan Africa. To the best of my knowledge, this is the first study in sub-Saharan Africa regarding the estimation of infrastructure development and international trade nexus. This study therefore fills this research gap by examining the infrastructure development and international trade nexus in sub-Saharan Africa taking into account the crucial nature of infrastructure in promoting international trade especially in developing economies like those located in sub-Saharan Africa.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter of the study explains the methodological approaches which the study adopts in achieving the various objectives outlined. Some of the sub-headings are scope of the study, the research design employed, data and data sources, measures of the variables used in the study such as the proxies for infrastructure development which includes, Gross Fixed Capital Formation (GFCF), Information and Communication Technology Adoption (ICT Adoption), and Port Development (PD). Further, measures of international trade include Imports (IM), Exports (Ex) and Trade Openness (TO) as well as the measures of institutional quality which is made up of Regulatory Quality (RQ), Political Stability (PS), Control of Corruption (CoC) and Government Effectiveness (GE). Some of the controls employed were Population (PoP), Government Expenditure (Gov Exp), Real Gross Domestic Product (RGDP) and Inflation (Inf). Then come sectoral value adds, which include the manufacturing, service, and agriculture sectors. The model estimate used in the research and the empirical methodologies are further discussed.

3.2 Research Design

According to Pastore (2017), a research design is the strategy used by researchers to match their hypotheses, techniques, procedures for collecting data and methods for analysing that data with the study's objectives. Additionally, it provides instructions on conducting research questions based on the responses and evaluating the study hypothesis. Further, the research design is a set of steps that direct the study's development and enforce a methodical approach to increase the efficiency of the

researcher. The study needs to use a methodical approach to investigating infrastructure-international trade nexus in sub-Saharan Africa to produce a more desirable outcome, both planned and unintended.

The study aims to investigate infrastructure-international trade nexus in sub-Saharan Africa for trade volumes to increase in this part of the globe despite the numerous trade agreements in place. A causal design is used, depending on the study's nature, to make it easier to communicate the findings uncovered. Moreover, Mingers, (2004) state that for the goal of estimating the causality between variables, causal design focus on specific characteristics of a chosen population of individuals at a certain moment. Additionally, a causal design allows gathering data on beliefs, attitudes, and motivations (Burns & Grove, 2003). The study therefore employs the descriptive research in examining the infrastructure-trade nexus.

3.3 Data and Data Sources

In estimating the nexus between infrastructure development and international trade, the study employed data from different sources such as World Development Indicators (WDI) and Global Competitive Index (GCI). It is worth noting that all the variables were selected for the study because of data availability and the duration required for the study.

3.4 Measures of Variables

This section of the chapter in the study details the variables employed in the study. In this section, the study explained the measures of all the variables employed in the study and how the variables were measured with regard to the data used. For instance, the study explained the measures of infrastructure development, international trade, institutional quality, the sectors employed, and the control variables used in the study.

Also, a brief description of the sectors or industries used in estimating the sectorial effects.

3.4.1 Measures of Infrastructure Development

Infrastructure development is the independent variable in the study. The study measured infrastructure development with three variables: Port Development, Gross Fixed Capital Formation, and ICT Adoption. The choice of these variables was based on literature and data availability. It is essential to note that the study proxied infrastructure development with both soft and hard infrastructure as well as social and economic infrastructure.

3.4.1.1 Gross Fixed Capital Formation (GFCF)

One of the factors affecting infrastructure development is gross fixed capital formation. The infrastructure capacity of most nations is often measured by gross fixed capital formation (GFCF) which shows the infrastructure capacity of the country in question (see Bist, 2018; Trojette, 2016). The research used gross fixed capital formation to gauge infrastructure quality and serve as a stand-in for infrastructure development. Gross Fixed Capital Formation was measured as a percentage of gross domestic product. Gross fixed capital formation is chosen because it has been used extensively in infrastructure development literature (Sare, 2019).

3.4.1.2 Port Development (PD)

This is also an infrastructure variable. Port planning and development include the assessment of port development plans and projects, data gathering and forecasting, stakeholder relations management at ports, and the strategic port planning process. Any project that involves engineering, rehabilitation, building, operation, or maintenance, in full or in part, including pre-project planning costs, is referred to as a port development project. This is where plans are put in place to improve the conditions at

the port of various countries, especially those in sub-Saharan Africa. The development of ports is key towards international trade because it allows goods to be transferred from one country to the others. This makes the development of ports crucial to international trade. The study measured port development as a percentage of Gross Domestic Product (Trojette, 2016). The choice of port development has been used extensively in the infrastructure development literature (Sare et al., 2018).

3.4.1.3 ICT Adoption

This was the last and final variable employed to measure infrastructure development in the study. The usage of information and communication technologies (ICTs) tools, such as computer hardware, software, and networks needed for connecting to the internet to make things easier especially in business, is referred to as ICT adoption. a company's adoption of information and communication technologies. The Digital Adoption Index (DAI) is a global index that evaluates how well a nation has embraced digital technology in three areas of the economy: people, government, and industry. Regarding infrastructure development and international trade, the study concentrates on the adoption of technology in the government to improve its trade activities with other countries (Trojette, 2016). The choice of ICT adoption has been used extensively in infrastructure development pieces of literature (Sare, 2019).

3.4.2 International Trade Measures

This is the study's dependent variable. Imports, exports, and trade openness were the three variables used in the research to assess global trade and serve as a proxy for international trade. These measures were selected based on the extensive literature reviewed and the fact that data for them are readily available. Therefore, it is crucial to emphasise that the research used trade volume inflows (imports) and outflows (export)

as well as the aggregate of these variables (trade openness) to represent international trade.

3.4.2.1 Imports (IM)

Any product or service that is acquired outside of the country of origin is considered an import. Imports are one of the main components of global trade. If a nation's imports are more than its exports, it is said to have a negative trade balance of payment, or a trade deficit. The research calculated the total amount of imports used in the study as a proportion of gross domestic product. The decision to proxy international trade with import is supported by a thorough literature review, revealing its extensive usage (Sare et al., 2018).

3.4.2.2 Exports (EX)

Exports are goods or services that are produced in one country and sent to another for resale in the country of origin. Exports are one of the main components of global trade. If a nation's imports are more than its exports, it is said to have a negative trade balance, or a trade deficit. The research calculated the total amount of exports used in the study as a proportion of gross domestic product. The decision to proxy international trade with export is supported by a thorough literature review, revealing its extensive usage (Sare et al., 2018).

3.4.2.3 Trade Openness (TO)

The sum or the combination of an economy's import and export transactions is known as trade openness. The degree to which a nation participates in the world trading system is gauged by its trade openness. Further, the proportion of the gross domestic product used to measure this variable. Trade openness is one of the most often utilised macroeconomic variables in modern and older research or studies. The act or practise of nations or economies dealing with one another or amongst themselves is known as

trade openness. Many academics and researchers have employed trade openness extensively in their research, including but not limited to (Sare et al., 2018). The ratio between the total of exports and imports against the gross domestic product is the main metric used to determine trade openness in this study. In research on infrastructure development, the concept of trade openness has been frequently employed (Kumi et al., 2017).

3.4.3 Measures of Institutional Quality

Institutional quality serves as the mediating role between infrastructural development and international trade in sub-Saharan Africa. This is where the study examines if there are any effects when institutional quality is keenly watched within the corridors of infrastructure and trade in sub-Saharan Africa. The study proxied institutional quality with four variables, including Control of Corruption, Regulatory Quality, Government Effectiveness and Political Stability. Data for these variables were gleaned from the Global Competitive Index website.

3.4.3.1 Control of Corruption (CoC)

This affects the institution's quality in some way. Controlling corruption refers to the removal of governmental authority or bureaucratic restrictions that are used for personal gain and that may impede the activities of foreign investors or entrepreneurs in general. This occurs in trade when someone bribes government officials to import or export something that is illegal or that they wish to refrain from paying duties on. The ability of a country to reduce these corruption-related activities have the impact of improving international trade. The study measured control of corruption with an index where 100 is the highest and 0 is the least. The choice of control of corruption has been used extensively in economic literature (Sare et al., 2018).

3.4.3.2 Regulatory Quality (RQ)

This is another variable of institutional quality. Concerning regulatory quality, it gathers opinions on how well governments can create and carry out sensible laws and rules that allow for or encourage the growth of the private sector. This is where the government makes the business environments serene and conducive for individuals in the private sector to get involved especially in the issue of international trade. The study measured regulatory quality with an index where 100 is the highest and shows that the government provides quality environment for businesses to strive and 0 is the least, indicating an intimidating business environment. The choice of regulatory quality has been used extensively in economics literature (Sare et al., 2018).

3.4.3.3 Government Effectiveness (GE)

In terms of international trade, this is yet another factor or indicator of institutional quality. Government effectiveness encapsulates perceptions of the calibre of the civil service, the calibre of the public service, the extent of its autonomy from political influences, the calibre of the creation and execution of policies, and the legitimacy of the government's adherence to such programmes. A good government effectiveness in an economy or country improves the quality of services provided. The study measured government effectiveness with an index where 100 shows high effectiveness from the government and 0 shows low effectiveness from the side of the governments. The choice of government effectiveness has been used extensively in economics literature (Kumi et al., 2017).

3.4.3.4 Political Stability (PS)

This is the last variable used to measure institutional quality. Stability is the quality of being unchanging. Political stability is the degree to which the governments of a country only change after a democratic election. This is where coup d'état issues are

minimised or nonexistent, and the country enjoys peace. The study therefore measured political stability with an index where 100 indicates high political stability and 0 also represent high political instability. Adopting political stability has been used extensively in economics literature (Kumi et al., 2017).

3.4.4 Control Variables

Control variables for the research were chosen with extensive consideration of previously published literature (both theoretical and empirical). They control variables of the study consist of population, real gross domestic product, government spending, and inflation.

3.4.4.1 Inflation (Inf)

A sustained increase in the average price of goods and services throughout the course of an economy is referred to as inflation. According to previous empirical research, inflation was employed as a stand-in for macroeconomic instability (see Kumi et al., 2017; Ibrahim & Alagidede, 2017; Ibrahim & Alagidede, 2018). The consumer price index (annual percentage) was used in the research to quantify inflation. Inflation (consumer prices) was included in the research because economists have long used it to gauge macroeconomic instability. This gives the justification for its usage in this study.

3.4.4.2 Government Expenditure

This metric calculates the government's overall spending as a proportion of gross domestic product. Government expenditure comprises all current government spending, such as paying wages, benefits for workers, and spending on security and defence, among other things, but does not include capital creation costs. Among the previous studies that used government expenditure was Doku et al. (2022). The study calculated government expenditure as the total amount the state or the government

spends as a share of the economy's gross domestic product. Government expenditure was included in this analysis since previous economic literature have extensively used it.

3.4.4.3 Population (Pop)

A population may be considered the whole group of people living in a certain area and at a specific period. The population was employed in the study because it is often and consistently used in research on foreign trade and because residents are the intended market for trade for all the goods produced. According to the past study's findings (Ibrahim & Alagidede, 2017), population growth rates were used as a proxy for population. Many academics and scholars have used population growth to research the factors influencing international trade.

3.4.4.4 Real Gross Domestic Product (RGDP)

Typically, this real gross domestic product represents the overall production of each economy in a country. It is also used to gauge a nation's productivity levels to assess whether the economy or nation is doing well. Regarding the infrastructure-trade nexus, real gross domestic product has been widely and extensively used in literature (see, for example, Kumi et al., 2017; Ibrahim & Alagidede, 2018). In their different studies regarding the connection between international trade and the infrastructure development of developed economies, several academics and scholars have used the real domestic product as a control variable in the various studies.

3.4.5 Sectoral value additions

The three (3) sectors available to the study, agriculture sector value addition, services sector value addition, and manufacturing sector value addition, were chosen for the study's estimation of the value addition of the respective sectors. The study, therefore, made use of past research conducted using sectorial effects (Ductor & Grechyna, 2015;

Ibrahim & Alagidede, 2017; Kumi et al., 2017) and utilised each sector's individual value contribution as a proxy or measure to measure the contribution of each sector.

3.4.5.1 Agricultural Sector Value Addition

In the context of this research, agricultural value addition is the whole output from the agricultural industry over a period, mostly annually. The agriculture sector of the sectorial value addition was represented by the agricultural value addition of each country in the sub-Saharan Africa which was selected. In studies on international trade, the option of the agricultural sector value addition has been utilised widely and extensively (Sare, 2019; Ductor & Grechyna, 2015).

3.4.5.2 Services Sector Value Addition

The value addition in the services sector encompasses all value additions in that sector, including transportation, business, and individual services like real estate, healthcare, and education. The study's assessment of the service industry's contribution to sectoral value addition was its value addition to the service sector over an annual period. The service sector value addition choice has been heavily referenced in the world of economic literature and research on international trade (Sare, 2019; Ductor & Grechyna, 2015).

3.4.5.3 Manufacturing Sector Value Addition

This is also one of the sectors in an economy that is of great interest in the study. Manufacturing sector value addition comprises all operations involved in the production of goods and services on the continent, especially in sub-Saharan Africa, which are included in the manufacturing sector value addition. The use of manufacturing sector value addition is because of its extensive usage in the world of economic literature and studies. Some of the scholars who have used manufacturing

value addition include but are not limited to Ibrahim & Alagidede (2016) and Kumi et al. (2017).

Table 3. 1: Measure of Variables, their sources and expected sign.

Variable	Notation	Data source	Expected Sign
Dependent Variables			
Import	IM	World Development Indicators	Negative
Export	EX	World Development Indicators	Positive
Trade Openness	TO	World Development Indicators	Positive
Independent Variables			
Gross Fixed Capital Formation	GFCF	World Development Indicators	Positive
Information Communication Technology Adoption	ICT Adoption	Global Competitive Index	Positive
Port Development	PD	World Development Indicators	Positive
Mediating Variables			
Control of Corruption	CoC	Global Competitive Index	Positive
Political Stability	PS	Global Competitive Index	Positive
Regulatory Quality	RQ	Global Competitive Index	Positive
Government Effectiveness	GE	Global Competitive Index	Positive
Controls Variables			
Government Expenditure	Gov Exp	World Development Indicators	Positive
Inflation	Inf	World Development Indicators	Negative
Population	Pop	World Development Indicators	Positive
Real Gross Domestic Product	RGDP	World Development Indicators	Positive

3.5 Model Estimation

The empirical approach used in the study to accomplish the study's goals is described in depth in this section. This section also goes into detail about the empirical approach taken to study how infrastructure development affects international trade in sub-Saharan Africa, the transmission channel through which this affects trade, the threshold effects that result when infrastructure in sub-Saharan Africa develops above or below the threshold, and how to model and demonstrate whether the effects of infrastructure development The research also investigates how institutional quality influences the relationship between commerce and infrastructure in sub-Saharan Africa. For the study's objectives to be met, these model estimates are done in accordance with each one.

3.5.1 Objective 1: Effects of Infrastructure Development on International Trade in sub-Saharan Africa

To examine the nexus of international trade and infrastructural development in Sub-Saharan Africa, the studyuses a panel dataset. This study seeks to understand how infrastructure development affects trade in Sub-Saharan Africa, particularly considering the numerous trade agreements that have been made to promote trade but have not enjoyed their various impact yet, as trade volumes in this part of the continent and globe is still low and on a constant reduction, such as the African Continental Free Trade Agreement (AfCFTA). Equation (1), which states that international trade depends on infrastructure development and other factors, is used to determine the impact that infrastructural development has on it experimentally:

$$IT_{it} = f(IF_{it}, C_{it}, \varepsilon_{it}) \quad (1)$$

$i = 1, 2, \ldots\ldots, N; \quad t = 1, 2, \ldots\ldots, T,$

where IF_{it} stands for the indicators of infrastructure development (gross fixed capital formation and port development, or ICT Adoption) of country i at time t; C_{it} stands for the control variables (inflation, gross domestic product, and trade openness); subscripts i and t are country and time indices, respectively; ε_{it} is the error term. As mentioned above, the control variables utilised in the research have been used in other studies on the relationship between infrastructure development and global trade (see Sare, Davies, & Nyeadi, 2022; Davies, Sare, Ibrahim, & Agoba, 2021).

$$IT_{it} = \alpha_o IT_{it-1} + \alpha_1 IF_{it} + \alpha_2 C_{it} + \epsilon_{it} \quad (2)$$

$$\epsilon_{it} = \gamma_i + \mu_t + \varepsilon_{it}$$

In this spirit, α_o is therefore used to examine whether Sub-Saharan Africa's level of international trade meets at a common steady-state; γ_i is the country-specific fixed effects; μ_t is the time effects while ε_{it} is the error term assumed to be independently and identically distributed, *iid* $N(0, \sigma^2)$.

In another scenario, the study also identifies the channel by which IF influences IT. Given the level of economic development in Sub-Saharan Africa, there is a multiplicative interacting term between IF and EG, which leads to the following estimation of equation (3):

$$IT_{it} = \varpi_o IT_{it-1} + \varpi_1 IF_{it} + \varpi_2 C_{it} + \theta(IF_{it} \times EG_{it}) + \epsilon_{it} \quad (3)$$

Where EG_{it} is economic growth for country *i* at time *t*, represented by Real Gross Domestic Product (RGDP) while the other variables are as previously defined. From equation (3), θ measures the impact of IF on IT given the countries' economic growth. Indeed, the introduction of a lagged dependent raises issues on endogeneity as the lagged dependent may be correlated with the error term (Greene, 2003).

Therefore, this study uses the system generalized method of moments (GMM) dynamic pooling estimator created by Arellano and Bond (1991) and Arellano and Bover (1995) to estimate equation (4). The generalized method of moments technique corrects the econometric issues of endogeneity of the lagged dependent as well as the unobserved country-specific effects common in panel estimations of this kind, as opposed to the traditional co-integration and ordinary least squares (OLS) estimations which were used in some of the previous studies. A general system GMM framework is given from equation (2) as follows:

$$IT_{it} = \sum_{k=1}^{p} \gamma_k IT_{it-k} + \alpha_1 IF_{it} + x_{it}\omega + \epsilon_{it} \quad (4)$$

$$t = p + 1, \ldots\ldots\ldots, T; \quad i = 1, 2, \ldots\ldots N$$

Where ω is the regressors while p is the maximum lag in the model.

The error term must be uncorrelated with the regressors to estimate equation (2) in the presence of endogeneity. This limitation necessitates the adoption of instrumental variables that affect regressors to have an impact on international trade. The values of present and historical international trade flows must not correlate with future realizations of the disturbance term, making our set of regressors weakly exogenous.

3.5.2 Objective Two: Explore the transmission channels through which infrastructural development affects international trade in sub-Saharan Africa in the short and long run

This section describes the empirical approach used to accomplish the study's goals. This section also details the empirical approach taken to investigate how the development of infrastructure affects global trade, particularly in sub-Saharan Africa, as well as the transmission mechanism that makes this happen. This research looks at how

infrastructure development affects international commerce via sectorial value additions in Africa and the effect it has on trade overall. We used panel data to investigate the connections between infrastructure development, global commerce, and sectoral value additions. For instance, Asteriou & Hall (2011) and Gujarati & Porter (2009) contend that pooled Ordinary Least Square imposes homogeneous intercept and slope parameters that conceal country-specific variation, possibly enabling the error component to correlate with certain regressors. However, when certain regressors are endogenous and linked with the error terms (Campos & Kinoshita, 2008), fixed effects provide a considerable bias (Baltagi, 2008). According to Arellano (2003), since random-effects models are time-invariant, the error term at any point may display strict exogeneity and not be correlated with past, present, or future series. Given these issues, the dynamic panel developed by Pesaran et al. (1999) is used in this work. This panel advises using the mean group (MG), which averages values from several countries, while the pooled mean group (PMG) pools long-run parameters.

According to Pesaran et al. (1999), the adoption of PMG is further justified since it restricts the equality of the long-run coefficients across nations while allowing considerable variation in the intercept, error variances, and short-run estimators. Therefore, PMG provides significant benefits over conventional techniques. First, the error terms were not serially associated and were separately distributed across the regressors. Second, despite parameter homogeneity, PMG generates reliable and effective long-run estimates. Due to the aforementioned factors, this research employs PMG, which combines the effectiveness of pooled estimate while preventing inconsistency issues by pooling heterogeneous dynamic nexuses.

This research establishes a model in which international trade is a function of infrastructural development and sectorial value addition, as illustrated in equation (5), to analyse the effects of these factors on international trade.

$$IT_{it} = f(IF_{it}, SVA_{it}, \varepsilon_{it}) \quad (5)$$

where IT_{it} is international trade indicators (import and export); IF_{it} is infrastructural development (Gross Fixed Capital Formation, Port Development and ICT Adoption); SVA_{it} are sectoral value additions comprising agricultural, service, and manufacturing sectors, which the study, respectively, denotes as $AGR_{it,}$ SER_{it}, and $MANU_{it}$; i and t are country and time indices, respectively; and ε_{it} the error term measures the influence of other variables not captured in the international trade equation. From equation (5), we impose the following Cobb-Douglas production function in equation (6).

$$IT_{it} = f(IF_{it}^{\tau}, SVA_{it}^{\varphi}, \mu_{it}^{\varepsilon}) \quad (6)$$

By explicitly writing equation (6) and introducing a constant, we arrive at equation (7).

$$InIT_{it} = \tau InIF_{it} + \varphi InSVA_{it} + \varepsilon_{it} \quad (7)$$

The coefficients in Equation (7) can be interpreted as elasticity. Because this study imposes a Cobb-Douglas production function, $\tau + \varphi = 1$. Because the study relies on three sectorial value additions, it further explicitly models equation (8) as:

$$InIT_{it} = \tau InIF_{it} + \varphi_1 InAGR_{it} + \varphi_2 InSER_{it} + \varphi_3 InMANU_{it} + \varepsilon_{it} \quad (8)$$

From equation (4), $\tau + (\varphi_1 + \varphi_2 + \varphi_3) = 1$ where τ measures the contribution of infrastructure development to international trade, φ_1, φ_2, and φ_3 respectively, measure the contributions of agricultural, service, and manufacturing sector value additions to international trade in Africa. Following Pesaran et al. (1999), this study introduces the

fixed effects estimator to estimate the pool mean group (PMG), as shown in equation (9):

$$InIT_{it} = \partial_i + \tau InIF_{it} + \varphi_1 InAGR_{it} + \varphi_2 InSER_{it} + \varphi_3 InMANU_{it} + \varepsilon_{it} \quad (9)$$

i = 1, 2, ……, t = 1, 2, ……, ; where ∂_i is the fixed effect.

To examine the transmission channels of the infrastructural-international trade nexus, this study introduces an interactive term for IF_{it} and SVA_{it} into the international trade equation in (6). Specifically, the study formulates the following equation where the indirect effect of finance is measured by ψ:

$$InIT_{it} = \partial_i + \xi InIF_{it} + \gamma_1 InAGR_{it} + \gamma_2 InSER_{it} + \gamma_4 InMANU_{it} + \varepsilon_{it} \quad (10)$$

Where ξ, γ_1, $\gamma_2$and $\gamma_3$are the parameters for infrastructural development, agriculture, service, and manufacturing sectors, respectively. Equation (10) is formulated in an autoregressive distributed lag (ARDL) framework to permit the dependent variable – international trade–to adjust to variations in infrastructural development and other changes in the independent variables. Specifically, this study estimates the PMG of Pesaran et al. (1999) using the ARDL (p, q) technique specified in Equation (11) as

$$\Delta(InIT_i)_t = \delta_i\left[(InIT_i)_{t-1} - \left\{\theta_{0,i} + \theta_{1,i}(InQ_i)_{t-1}\right\}\right] + \sum_{j=1}^{p-1} \alpha_{i,j}\Delta(InIT_i)_{t-j} + \sum_{j=0}^{q-1} \gamma_{i,j}\Delta(InQ_i)_{t-j} + \varepsilon_{i,t} \quad (11)$$

i = 1, 2, ……, t = 1, 2, …….

where Q represents the regressors including IF_{it}, AGR_{it}, SER_{it}, and $MANU_{it}$ and the multiplicative interactive term of IF and SVA; α and γ are the short-run coefficients related to international trade and its drivers; θ_i are long-run coefficients; δ_i is the

coefficient of the error correction term that measures the speed of adjustment to long-run equilibrium; and ε represents the time-varying disturbance. Indeed, from the ARDL framework, the PMG estimations produce consistent estimates with the lag orders p and q suitably chosen.

3.5.3 Objective 3: Determine whether the effects of infrastructural development on international trade in sub-Saharan Africa is threshold specific

This research aims to look at any potential nonlinearities in the relationship between global commerce and infrastructure development. The use of yearly time series data to analyse potential thresholds and the influence of infrastructure development on international commerce results from the fact that the objective of this research is to consider each variable as an independent unit of analysis, making panel data unsuitable. In fact, a conventional approach to analysing such a threshold effect of infrastructure development on international trade entails including a quadratic term of infrastructure development in addition to some controls in the equation for international trade (see, for example, Gächter & Gkrintzalis, 2017). Such a method specifically regresses the equation shown below:

$$IT_{it} = \Upsilon_o + \Upsilon_1 IF_{it} + \Upsilon_2 {IF_{it}}^2 + \Upsilon_3 C_{it} + \varepsilon_{it} \quad (12)$$

t = 1, 2, …….,

Where IT, IF and IF^2 respectively denote indicators of International Trade [Import and Export], infrastructure development [Gross Fixed Capital Formation, Port Development, and ICT Adoption] and the square term of infrastructure development, respectively. The square term of infrastructure development measures nonlinearity in infrastructure-trade nexus; C_{it} is the control variables [inflation, population, Real Gross

Domestic Product, and government expenditure] while ε_{it} is the error term and *t* are the time index.

The trade-economic growth nexus (Kim & Lin, 2009; Zahonogo, 2016) and the finance-economic growth nexus (Ibrahim & Alagidede, 2017) are two areas where this threshold method has been heavily applied. However, this method ignores the possibility that the effect of infrastructure development on global commerce may be significantly influenced by the infrastructure development of individual nations, apart from the fact that it imposes exogenous nonlinearity. Because Hansen's (2000) sample splitting technique uses asymptotic theory to determine the threshold, it departs from the previous strategy described above. This method has also been used to determine the effects of financial development on mortgage financing in Africa (see Davies, Sare, Ibrahim & Agoba, 2021) and to examine the links between fiscal policy and economic activity in developing nations (Slimani, 2016) and SSA (Ibrahim & Alagidede, 2017). Hansen's (2000) sample splitting method calculates the regression parameters using least square estimation, which reveals the precise characteristics of each threshold as well as their statistical significance. To use this strategy, we alter equation (12) such that the degree of infrastructure in sub-Saharan Africa acts as a buffer between the precise effect of infrastructure development and global commerce. In contrast to prior research, this one contends that the degree of infrastructure development in a nation determines whether it helps or harms international commerce. As a result, the threshold value is treated as a continuous distribution, and equation (13)'s parameters are calculated. Then, using the single equation below, we estimate a two-regime threshold model:

$$IT_{it} = \begin{cases} (\alpha_{11} + \alpha_{21} IF_{it} + \varepsilon_{it}) & \text{for} \quad d_{it}\{q_{it} \leq \eta\} \\ (\alpha_{12} + \alpha_{22} IF_{it} + \varepsilon_{it}) & \text{for} \quad d_{it}\{q_{it} > \eta\} \end{cases} \tag{13}$$

This type of modelling approach is crucial and suitable as it permits the impact of infrastructure development to differ on whether gross fixed capital formation, port development and /or ICT adoption are below or above some unknown threshold value of η. Thus, the level of infrastructure development in equation (13) acts as a sample splitting or threshold variable. On this score, the effect of infrastructure development on international trade is respectively measured by α_{21} and α_{22} for a country with infrastructure development below and above the threshold.

The study, therefore, limits the threshold value η to a bounded set, $\eta \in [\underline{a}, \overline{b}] = \psi$ while using the concentration approach to estimate the least-squares estimators where $\hat{\eta}$ is the unique value that minimizes the Sum of Squared Errors (SSE), $SSE_n(\eta)$ and can, therefore, be estimated as:

$$\hat{\eta} = \underbrace{argmin}_{\eta \in \psi_n} SSE_n(\eta),$$

where $\psi_n = \psi \cap \{q_1, q_2, \ldots\ldots\ldots, q_n\}$.

Indeed, from equation (13), if $\alpha_{21} = \alpha_{22}$, the model reduces to a linear one. Therefore, as the first step in this approach, the study tests the hypothesis for the existence of thresholds. The null hypothesis $H_0: \alpha_{21} = \alpha_{22}$ argues that the equation is linear against the alternative hypothesis ($H_1: \alpha_{21} \neq \alpha_{22}$) of a threshold model. Under the assumption that the error term is *iid* $N(0, \sigma^2)$, the hypothesis is tested using the Likelihood Ratio (*LR*) test statistic:

$$LR_n(\eta) = n\frac{SSE_n(\eta) - SSE_n(\hat{\eta})}{SSE_n(\hat{\eta})}$$

We reject the $H_0$for large values of $LR_n(\eta)$ and by rejecting this hypothesis, we find evidence of a threshold. In this study, full nonlinearity (or threshold) is when a country

exhibits a threshold for both proxies of infrastructure at all the indicators of international trade. However, a country is said to exhibit an incomplete nonlinearity when there is evidence of a threshold for at least one indicator of infrastructure and trade.

3.5.4 Objective 4: The role of Institutional quality on infrastructural development and international trade nexus in sub-Saharan Africa

This was the fourth and final objective of the study. In this objective, the study intends to know the mediating role that infrastructure development plays in improving international trade by taking a critical look at the institutional quality variables such as political stability, control of corruption, regulatory quality, and government effectives. This objective was critical to determining whether institutional quality promotes or inhibits international trade in sub-Saharan Africa.

The study employed the use of Partial Least Square (PLS) to estimate the mediating role of institutional quality in infrastructure-international trade nexus. In the context of structure-activity correlation, Partial Least Square (PLS) offers several advantages over regression analysis. These advantages encompass the capability to effectively handle a larger number of descriptor variables compared to compounds, accommodate non-orthogonal descriptors, and account for multiple biological outcomes. Furthermore, PLS demonstrates enhanced predictive accuracy and significantly reduces the likelihood of chance correlation.

3.5.4.1 Sample Selection

According to Fielding et al. (2012), a good sample represents the population from which information can be acquired and analysed that can produce results consistent with those that would have been reached if information had been gathered on the entire population. Therefore, if consistency and dependability of results are to be attained, the study must

concentrate on the sample size of their research (Hair et al., 2012). The PLS-SEM principles were followed to ensure sample adequacy. Path modelling using partial least squares (PLS), a multivariate statistical technique, uses the alternating least squares algorithm. The PLS-SEM approach for determining the minimum sample size most frequently employed is the "10-times rule" method (Hair, Ringle & Sarstedt, 2011; Peng & Lai, 2012). The minimum sample size for a study should, according to the "10-times rule," be greater than "10 times" the highest number of inner or outer model linkages that relate to any of the model's constructs (Goodhue, Lewis, Thompson & Thompson, 2012). Based on the above principle, institutional quality has the most indicators (4 indicators); a minimum sample size of 4*10=40 is therefore required for this study, by the "10-times rule." Therefore, this study requires a minimum of 40 countries. However, this study exceeded the "10-times" rule's minimum sample size requirement by engaging 43 countries in sub-Saharan Africa. The choice of 43 countries in sub-Saharan Africa is ideal for the study as it meets the minimum sample size requirement. The objective moved away from the panel data estimation and adopted the cross sectional over the year 2020.

CHAPTER FOUR

FINDINGS AND DISCUSSIONS

4.1 Introduction

This chapter entails the empirical findings of the study. The findings for the study are categorized into four sub-sections per the objectives outlined in the study. From the study, each objective was analyzed separately and independently. The reason for each objective to be analyzed separately and independently is that some of the variables were further added to the objective to enable the objective to be achieved. For instance, one variable for the independent variable was further added in objectives two and three and a mediating variable in objective four. Most of the objectives outlined in the study have different data sets. This makes it viable for the study to examine each objective separately and independently.

4.2 Objective One: Effects of Infrastructure Development on International Trade in sub-Saharan Africa

This is the first objective that the study spelt out to achieve. With this objective, the study seeks to examine the overall effects of infrastructure development on international trade in sub-Saharan Africa considering the level of economic growth of countries located on this continent. This objective tends to investigate if infrastructure improves in this sub region, will it have any impact on international trade considering the level of economic growth seen in this part of Africa.

4.2.1 Preliminary Findings

This section of the chapter provides details into the initial discussions of the study, which comprises the descriptive statistics and correlation co-efficient of all the variables employed to achieve this objective.

4.2.1.1 Descriptive Statistics

This is an aspect of the preliminary findings of this objective. The descriptive statistics describe the behavior of all the variables adopted to achieve this objective. The mean, standard deviation, maximum, minimum, skewness, kurtosis, co-efficient of variation, and observations of variables like imports, exports, gross fixed capital formation, and government spending, to name a few, are all included in the descriptive statistics. The descriptive statistics for the variables for the years 1985 to 2020 are shown in Table 4.1.

Table 4. 1: Descriptive Statistics

	IM	**EX**	**GFCF**	**PD (ICT)**	**RGDP**	**Inf**	**Gov Exp**	**Pop**
Mean	34.032	25.391	17.996	22.313	3.808	37.139	12.969	2.535
Std. Dev	22.954	18.927	11.512	13.711	7.049	631.864	8.115	1.084
Max	42.343	34.695	23.969	28.152	6.247	248.120	22.009	4.716
CV	0.674	0.745	0.640	0.614	1.851	17.013	0.626	0.428
Skewness	2.045	1.070	0.689	1.064	6.156	34.729	0.734	-1.434
Kurtosis	14.312	4.254	5.331	5.155	133.074	1290.669	5.301	12.972
Obs	1548	1548	1548	1548	1548	1548	1548	1548

Note: PD(ICT)=Port Development; IM=Import; EX=Export; GovExp=Government Expenditure; Pop=Population; Inf=Inflation; GFCF=Gross Fixed Capital Formation; RGDP=Real Gross Domestic Product; Std. Dev=Standard Deviation; Max=Maximum; CV=Coefficient of Variation: Obs=Observations.

It is clear from the table above (table 4.1) that Sub-Saharan African countries engage in more importing than exporting because the average import and export values presented for the period in question are 34.032 per cent of GDP and 25.391 percentage of GDP, respectively. Import values are more erratic than export values (18.927), which is indicated by knowing that import exhibits a standard deviation of 22.951. The greatest import figure for the time period was 42.343 % of GDP, which is noteworthy given that Sub-Saharan African countries are infamous for importing more than what they sell. However, with values for import and export of 2.045 and 1.070, respectively, the two variables are leptokurtic in nature and skewed to the right. Sub-Saharan African countries could be viewed as an imported part of Africa. It was found that the independent variables (GFCF and port development "ICT") had an average of 17.996% and a standard deviation of 11.512. As a result, the average investment for port (ICT) development in this region is 22.313% of GDP, compared to the average investment for infrastructure development via GFCF in this area, which is 17.996% of GDP. In addition, the port development (ICT) data shows that the kurtosis value is 5.155, which denotes leptokurtic behaviour with a positive skewness of all values (1.064). This shows that Sub-Saharan Africa has invested significantly in infrastructure, but more must be done, especially in the growth of ICT at the various ports in the region. RGDP represents the Sub-Saharan region's actual gross domestic products. It shows how they have grown and changed. According to Table 1 above, Sub-Saharan African countries only saw an average 3.808% growth in their economies from 1985 to 2020. It is interesting to note that there was a time when some of the countries saw a decline in growth, as indicated by the minimum value of -4.666. However, the combined greatest growth across all economies is 6.247, which is not a strong indicator of growth across nations. This demonstrates that the RGDP of nations in sub-Saharan Africa is low,

which may be related to the low level of economic activity in this region because of insufficient trade volumes. Additionally, the control variables include population, inflation, and government spending. The least figure was 37.139%, and the greatest was a staggering 248.120%, indicating that Sub-Saharan African nations are recognised for having significant inflation levels. This further indicates that inflation is a specific problem among Sub-Saharan African nations. It is alarming to see that just 12.96% of all money is spent by the government, and this further supports the infrastructure deficit. This could also be the case since most of the nations in the area are notorious for having significant debt or loan servicing. Population growth is measured by the number of people in each country overall. Accordingly, nations in sub-region in table 1 witnessed population increase of 2.535% throughout the period, with the largest growth reported being 4.716% and the lowest growth being 2.702%. This demonstrates the potential of sub-Saharan African nations in terms of market value or ready markets.

4.2.2 Correlation Co-efficient

Correlation co-efficient deals with the association existing between and among the variables employed in the study. The research proceeded to discover the relationship between and among the many variables used after describing the characteristics of each variable through descriptive statistics. The findings about how the variables show their relationships with and among one another are shown in Table 4.2 below.

Table 4. 2: Correlation Co-efficient

	IM	EX	GFCF	PD (ICT)	RGDP	Inf	Gov Exp	Pop
IM	**1.000**							
EX	0.670	**1.000**						
GFCF	0.396	0.422	**1.000**					
PD (ICT)	0.188	0.570	0.404	**1.000**				
RGDP	-0.003	-0.015	0.022	-0.014	**1.000**			
Inf	-0.047	-0.031	-0.053	0.004	-0.042	**1.000**		
Gov Exp	0.528	0.393	0.431	0.206	-0.088	-0.063	**1.000**	
Pop	-0.180	-0.080	0.061	0.062	0.166	0.044	-0.118	**1.000**

Note: PD (ICT)=Port Development; IM=Import; EX=Export; Gov Exp=Government Expenditure; Pop=Population; Inf=Inflation; GFCF=Gross Fixed Capital Formation; RGDP=Real Gross Domestic Product

Findings from Table 4.2 show a curious trend whereby import and export have a significant yet favourable relationship. This positive link between these elements may be caused by the competitive advantage dilemma, in which a country or economy focuses on goods it can produce at an inexpensive rate for export but imports goods where it faces costly disadvantages in the manufacturing chain. Import also developed a favourable relationship with GFCF and port development (ICT) in terms of proxies for infrastructure development, however in this instance, the relationship is rather marginal, with values of 0.396 and 0.188, respectively. This shows that the more a country in Sub-Saharan Africa imports, the higher its chances are of building its

infrastructure. This is true since importing products boosts economic activity because they may be sold again and, most significantly, because they are subject to duties at the port, which bring in money for the government. In Sub-Saharan Africa, imports were shown to have a negative but moderate relationship with real GDP, inflation, and population, but a positive and robust relationship with government spending. This is because importation of products lowers the nation's overall productivity levels, resulting in a low GDP and a low or negative RGDP. This may result from the significant importation carried out by African countries, particularly in Sub-Saharan Africa. It goes on to explain that imports often affect the economy, which high unemployment rates and low taxes may show. Regarding the correlation between export and other factors, it was found that export had a favourable correlation with the relevant variables (GFCF and port development through ICT). This indicates that commerce and infrastructure development are moving in the same direction in Sub-Saharan Africa. This suggests that the growth or enhancement of the infrastructure in sub-Saharan Africa serves as a conduit for export-based global commerce. The ability to order from other countries and continents is made feasible by the developing ICT networks in this area. While real gross domestic product, inflation, and population showed negative correlations with these factors, there is also an additional positive link with government spending, albeit a minor one. This demonstrates that government spending encourages exports, which could take the form of giving subsidies to the agricultural industry to help farmers produce enough goods to meet domestic demand before exporting to neighbouring nations or states. This demonstrates how important infrastructure development is to world commerce. When it comes to the proxies for infrastructure development, GFCF created a positive link with every factor save inflation, while construction only established a negative association with real domestic product. Real

domestic product also showed a negative correlation with government spending and inflation, but a positive correlation with population. It is interesting to see that government spending established a negative connection with the population, and that relationship was mirrored by inflation. In summary, it can be concluded that although most of the factors are favourable for Sub-Saharan Africa's infrastructure development, inflation is not.

4.2.3 Results and Discussion

To understand how infrastructural development encourages or discourages international trade in Sub-Saharan Africa, the study examines the relationship between infrastructure development and trade using two different methodologies. Imports and exports are used as proxy for trade internationally, individually and independently. This is done through trade numerous international trade agreements, such as the recent one known as AfCFTA. Table 4.3 demonstrates how the amount of infrastructure development in Sub-Saharan Africa, as measured by that region's economic growth, affects one variable of international commerce (import).

Table 4. 3: International Trade (Import)-Infrastructural Development Nexus

Variable	1	2	3	4
Constant	-5.887**	-2.576**	-3.722	-3.922
	(0.024)	(0.012)	(0.190)	(0.169)
Lag-Import	0.748***	0.801***	0.830***	0.849***
	(0.000)	(0.000)	(0.000)	(0.000)
GFCF	0.581***	-	-	-
	(0.000)555			
PD (ICT)	-	-0.033*	-	-
		(0.072)		
Gov Exp	0.602***	0.933***	0.989***	0.989***
	(0.000)	(0.000)	(0.000)	(0.000)
Pop	-1.515	-0.790**	-1.459**	-1.399**
	(0.015)	(0.047)	(0.032)	(0.041)
Inf	0.004	0.006***	0.001	0.001
	(0.279)	(0.000)	(0.227)	(0.239)
Channels				
GFCF x RGDP	-	-	0.005***	-
			(0.001)	
PD (ICT) x RGDP	-	-	-	-0.003*
				(0.095)
Diagnostics				
Number of Countries	43	43	43	43
Wald chi²	456.02***	289.47***	299.57***	288.29***
	(0.000)	(0.000)	(0.000)	(0.000)
Sagan Test	18.015	21.824	16.395	20.548
	(1.000)	(1.000)	(1.000)	(1.000)
AR (1)	-1.125*	-1.227*	-1.958*	-1.348*
	(0.051)	(0.068)	(0.073)	(0.080)
Observation	1548	1548	1548	1548

Note: PD (ICT)=Port Development; IM=Import; EX=Export; Gov Exp=Government Expenditure; Pop=Population; Inf=Inflation; GFCF=Gross Fixed Capital Formation; RGDP=Real Gross Domestic Product; ***, ** and * being 1%, 5% and 10% significant levels as well as ( ) denoting the p-values.

The study built four models to examine how infrastructural development affects international trade (imports) in Sub-Saharan Africa. Models 1 and 2 used infrastructural development variables, while models 3 and 4 considered the expansion of the various economies in Sub-Saharan Africa when examining its effects. It simply illustrates whether infrastructure improvement has any impact on global commerce given the present rate of economic growth in these Sub-Saharan African nations.

The importation of products and services has a positive and extremely significant influence on international commerce in Sub-Saharan Africa, as shown in Model 1, and this impact is considerable at 1%. This beneficial and large effect may be attributable to the imposition of taxes on imported products, which generates cash for the government and helps finance construction projects. By making products easily accessible to customers in every region of the nation via effective transportation, infrastructure development plays a crucial role in expanding the market for imported goods. The nation and the subregion's economies benefit from imported commodities. Even while most nations, particularly those with emerging economies like those in the Sub-Saharan African area, do not want to import commodities, the importance of this practise cannot be understated. Aside from generating income for governments, it also enables nations to import items not produced there but nevertheless seen as being of utmost importance. This result also shows that an increase in infrastructure-related development boosts global commerce by 0.581% per unit. Additionally, government spending has a positive and substantial influence on imports by 1%, showing that government spending in the Sub-Saharan African area promotes imports. This is because most goods purchased in Sub-Saharan Africa are manufactured in industrialised nations. Therefore, any money spent on these items results in increased imports. In other words, sub-Saharan African nations see a rise in imports of 0.602%

for every unit increase in government spending. This result aligns with what Cosar and Demir (2016) and Danaubauer et al. (2018) found in their separate research, which both showed that a lack of infrastructure hurts international trade. This demonstrates how important infrastructure development is and how it may improve commerce after implementing the AfCFTA for the advantages that member nations hope to get. However, in model 2, where port development is used as a proxy for infrastructure development, it is shown that infrastructure development has a detrimental but marginally significant influence on global commerce. This detrimental effect suggests that Sub-Saharan Africa's best option for lowering imports is increased investment in the development of industries. Infrastructure development via the development of the numerous ports has the propensity to impede international commerce in the area. This may also be due to the existence of other crucial infrastructures, such as ICT, which facilitates commerce and eliminates the need for port-based operations. A paperless port might be established, allowing people to do business without being physically there. The paperless port programme in Ghana is a prime example. Additionally, the findings indicate that a unit increase in port development investment (ICT) decreases imports by 0.033%. This is so because other variables improve commerce whether the port has evolved. However, this result runs counter to other findings (Ismail & Mahyideen, 2015; Rehman et al., 2020) that indicate infrastructure expansion stimulates commerce in emerging countries. Interestingly, only the population negatively influences foreign commerce, whereas all the other factors have a very significant impact of 1%. This unfavourable and substantial impact demonstrates that population does not facilitate commerce in the area, in contrast to Shepherd (2016) and certain trade theories, such as the Gravity Model. While Shepherd (2016) discovered in his research that a bigger population acts as a suitable market for products and services, the gravity model also

claims that a higher population results in a wider market base for production. Even if there is a foundation for a huge market with a greater population, the opposing results in this research of the Sub-Saharan African area are not unexpected since the region's (RGDP) has shown a noticeably low number. This indicates that, despite a bigger population, the region's customers have limited buying power, which results in poor trade volumes. The favourable influence on government spending and inflation may also be due to the causes mentioned above.

Another goal of the research was to evaluate the impact of infrastructure development on global commerce using model 3 and model 4 and the rate of growth of the major Sub-Saharan African economies. Model 3 illustrates how the expansion of economies in Sub-Saharan African nations significantly impacts world commerce. The GFCF and RGDP were seen to greatly benefit global commerce. This indicates that given a country's rate of growth together with infrastructure development, it tends to promote commerce, particularly in nations or economies in Sub-Saharan Africa. This further demonstrates that although infrastructure development might encourage commerce, for the benefit to be maximised, nations in the subregion must build their economies with sufficient infrastructure to boast the necessary quantities. The control variables continued to have their respective and substantial influence, as shown in model 2, even after the introduction of RGDP. According to the research, model 4 and model 3 have the opposite connection. This indicates that the influence of a country's growth and infrastructure development on commerce in Sub-Saharan Africa depends on the variable's measure of infrastructure development. According to the findings, it would be foolish for Sub-Saharan African nations to pay more attention to GFCF, as it has a positive effect on trade and has the potential to alter the agreement completely. This is

especially true given that the AfCFTA is now fully operational, with its headquarters in Ghana, a Sub-Saharan African region.

Table 4. 4: International Trade (Export)-Infrastructural Development Nexus

Variable	1	2	3	4
Constant	2.495 (0.185)	0.782 (0.675)	4.736** (0.010)	4.665** (0.014)
Lag-Export	0.845*** (0.000)	0.783*** (0.000)	0.799*** (0.000)	0.806*** (0.000)
GFCF	0.206*** (0.000)	-	-	-
PD (ICT)	-	0.215*** (0.000)	-	-
GovExp	0.082 (0.254)	0.222*** (0.001)	0.234*** (0.000)	0.249*** (0.000)
Pop	-1.366*** (0.002)	-1.174*** (0.006)	-1.390*** (0.001)	-1.361*** (0.002)
Inf	0.001** (0.028)	0.001* (0.051)	0.001** (0.022)	0.001** (0.029)
Channels				
GFCF x RGDP	-	-	-0.012*** (0.000)	-
PD (ICT) x RGDP	-	-	-	-0.001*** (0.000)
Diagnostics				
Number of Countries	43	43	43	43
Wald chi²	278.11*** (0.000)	300.43*** (0.000)	302.60*** (0.000)	275.65*** (0.000)
Sagan Test	19.264 (1.000)	18.657 (1.000)	21.354 (1.000)	16.245 (1.000)
AR (1)	-2.158* (0.051)	-2.458* (0.068)	-2.254* (0.073)	-2.021* (0.080)
Observation	1548	1548	1548	1548

Note: PD (ICT)=Port Development; IM=Import; EX=Export; Gov Exp=Government Expenditure; Pop=Population; Inf=Inflation; GFCF=Gross Fixed Capital Formation; RGDP=Real Gross Domestic Product; ***, ** and * being 1%, 5% and 10% significant levels as well as ( ) denoting the p-values.

The study further estimates the impact that infrastructure development has on international trade in Sub-Saharan Africa using export as a measure of trade after examining the effects of infrastructure development on import as a proxy for international trade.

In model 1, it is shown that infrastructure development has a favourable effect on global commerce. The correlation between GFCF (infrastructure development) and export (international trade) is positive, and it is very significant at 1%. It also shows that member nations' exports of products grow by an average of 0.206% for every unit improvement in the region's infrastructure development. This impact has a stronger propensity to reduce the balance of payments deficits that sub-Saharan Africa and all of Africa endure. It is conceivable in that items may be delivered to the different markets without any loss in value and in real time, particularly with perishable goods, when there is a robust infrastructure, such as excellent roads, a strong communication network, and ICT. Additionally, there is a greater chance that the commodities may be exported on time if they are carried on time owing to strong infrastructure, particularly if the items are perishable. Most of the products do not reach the intended markets in a timely manner owing to insufficient infrastructure, including substandard roads and a weak network, among other factors, making it difficult to increase exports. This is the present scenario in most Sub-Saharan African nations. Due to this, it is very challenging for them (countries in sub-Saharan Africa) to reap the benefits of the multiple trade agreements, including the most recent one, the AfCFTA. This demonstrates how infrastructure development in Sub-Saharan Africa influences global commerce in a beneficial way. Because of this, nations in Sub-Saharan Africa must strengthen its infrastructure foundation to reap the benefits of the AfCFTA, since the trade agreement cannot alone promote commerce given the region's infrastructural deficiencies.

Additionally, it was shown in model 2 that infrastructure development continued to have a favourable and considerable influence on global commerce. In this case, port expansion through ICT encourages global commerce. This is where the expansion of sub-Saharan ports reduces the costs of exporting commodities in terms of fees and the burdensomeness of the processes, freeing up time and energy that may then be used to increase economic activity in the subregion. Here, a 1% increase in port construction and growth results in a 0.215% rise in exports of products. All conversional levels are significantly impacted by this effect. Additionally, when the topic of infrastructure development and foreign commerce is broached, population and inflation are believed to be adversely and favourably influenced by 1% and 5%, respectively. Additionally, both government spending and inflation continue to have a favourable effect, but in this scenario, government spending is large at 1%. This indicates that when it comes to the export of commodities in different nations, government spending is quite important. In this case, it makes more sense for governments to invest in sectors that will advance global commerce than those that would obstruct it, most notably the agricultural industry. This further suggests that increased government spending per unit results in a 0.222% rise in export-related global commerce.

On the other hand, population showed a negative and substantial association with commerce. This is when a country's population growth, especially in Sub-Saharan Africa, obstructs foreign commerce (export). Here, output is often capped at levels that cannot adequately supply home markets or even certain exports, resulting in relatively little global commerce, particularly in exports. The problem is made worse when low-tech techniques are mostly used in the area to impede output. Creating and having surplus commodities and services that need new markets to be disposed of becomes challenging. This study refutes a previous claim made by Shepherd (2016) and other

trade theories, such as the Gravity Model, that population is one of the key factors of international trade, particularly in developing markets. It also shows that trade does not facilitate in the subregion. Most economies try to keep inflation under control since it is a crucial macroeconomic indicator. However, inflation is one of the biggest issues facing emerging economies, such as those in the Sub-Saharan African area. It is interesting to note that inflation in both models established a positive, albeit marginally significant, impact on the export of goods in the region, indicating that inflation is a crucial indicator that requires monitoring to support trade but does not spiral out of control to impact the region's long-term trade growth negatively.

Both the metrics of infrastructure development in models 3 and 4 had a detrimental effect on foreign commerce. Because of the sluggish rate of economic growth in the subregion, as shown by the low GDP data found in this research, nations in Sub-Saharan Africa do not currently benefit from their existing economic progress regarding international commerce. This may be one of the factors contributing to the low levels of export activity among Sub-Saharan African nations, which prevents them from reaping the full advantages of the many trade agreements they have signed.

4.3 Objective Two: The transmission channels through which infrastructural development affects international trade in sub-Saharan Africa in the short and long run.

This is the second objective of the study. In this objective, the study examines the transmission channels through which infrastructure development affects international trade in sub-Sharan Africa through the short and long-run sectors. The study established the various economic sectors with which infrastructure development improves international trade in sub-Saharan Africa or otherwise. In this objective, the study intends to know the short-term and long-term implications of infrastructure

development and international trade nexus on the various sectors in an economy. The following details the preliminary findings uncovered through the study for this objective. The study introduced new variables to achieve this objective. Some of the variables introduced include but are not limited to agricultural value addition, services value addition and manufacturing value addition.

4.3.1 Preliminary Findings

This section of the chapter provides details into the initial discussions of the objective, which comprises the descriptive statistics and correlation co-efficient of all the variables employed to achieve this objective.

4.3.1.1 Descriptive Statistics

This is a vital aspect of the preliminary findings for the objective. The descriptive statistic of this objective describes the behaviour of all the variables adopted to achieve the objective. The descriptive statistics contains the mean, standard deviation, maximum, minimum, skewness, kurtosis, co-efficient of variation, observations among others. Table 4.5 contains the descriptive statistics of the variables from 1985 to 2020.

Table 4. 5: Descriptive Statistics

	IM	EX	ICT	GFCF	PD	Agric	Service	Manu	RGDP	Inf	Gov Exp	Pop
Mean	34.032	25.391	15.056	17.996	22.313	20.986	40.241	9.186	3.808	37.139	12.969	2.535
Std. Dev	22.954	18.927	25.953	11.512	13.711	15.714	17.662	7.103	7.049	631.864	8.115	1.084
Max	42.343	34.695	39.110	23.969	28.152	79.042	82.586	50.637	6.247	248.120	22.009	4.716
CV	0.674	0.745	1.724	0.640	0.614	0.749	0.439	0.773	1.851	17.013	0.626	0.428
Skewness	2.045	1.070	5.953	0.689	1.064	0.566	-0.979	1.674	6.156	34.729	0.734	-1.434
Kurtosis	14.312	4.254	62.499	5.331	5.155	2.680	3.659	9.425	133.074	1290.669	5.301	12.972

Note: PD=Port Development; IM=Import; EX=Export; ICT=Adoption of Technology; GovtExp=Government Expenditure; Pop=Population; Inf=Inflation; GFCF=Gross Fixed Capital Formation; RGDP=Real Gross Domestic Product; Agric=Agriculture Sector; Service=Service Sector; Manu=Manufacturing Sector; Std. Dev=Standard Deviation; Max=Maximum; CV=Coefficient of Variation.

Table 4.5 above shows that Sub-Saharan African nations import more products than they export on average, with imports accounting for 34.032 percentage of GDP and exports for 25.391 percentage of GDP, respectively, throughout the period. This demonstrates that most necessities in sub-Saharan Africa are imported. The values for imports have a higher standard deviation (22.951) than those for exports (18.927). The largest value of imports throughout the period was 42.343 percentage of GDP since Sub-Saharan African nations are notorious for importing more than they sell. This indicates that about half of the region's total GDP during that period was spent on imports in sub-Saharan Africa. Despite being leptokurtic in nature, both variables are biased to the right, with values for imports and exports of 2.045 and 1.070, respectively. As a result, sub-Saharan African nations might be considered imported portions of Africa. GFCF had an average of 17.996% with a standard deviation of 11.512 when it came to the independent variables (GFCF, port development, and ICT adoption). This indicates that on average, the GFCF invests 17.996% of the region's GDP in infrastructure development, 22.313% in port development, and just 3.056% in ICT adoption. This indicates that a significant portion of investments made in sub-Saharan Africa are used to construct and expand several ports on this side of the continent. When infrastructure development is considered, ICT adoption is lowest. The kurtosis value for port development is 5.155, demonstrating its leptokurtic feature, while all its values are favourably skewed (1.064). This demonstrates that sub-Saharan Africa has made significant infrastructure investments, but more must be done, particularly in terms of ICT adoption and development nationally, particularly at the continent's many ports. RGDP represents the sub-Saharan region's actual gross domestic products. This demonstrates their maturation and growth. Over the study period (1985–2020), it was observed that the economies of Sub-Saharan African nations grew by 3.808%. It's

interesting to note that it reached a point when certain nations experienced negative growth, as shown by the minimum figure of -4.666%. This indicates that certain Sub-Saharan African nations "fell back" in developing their own economies. These intervals could be connected to the political unrest seen in the early phases of colonisation. However, the highest growth rate across all economies is 6.247%, which is not a strong indicator of growth across nations. This demonstrates that sub-Saharan African nations have low real gross domestic product (RGDP), which may result from the region's weak economic activity and insufficient or insufficient trade volumes. In addition, it was noted that nations in Sub-Saharan Africa are known to have significant inflation levels, with a minimum value of 37.139% and a maximum of 248.120%, with government spending, inflation, and population acting as the control variables. This further indicates that sub-Saharan African nations have a special problem with inflation. The government spends just 12.969% of the GDP of the entire money received, which is appalling and further supports the infrastructure deficit. This also implies that sub-Saharan African governments need more sources of funding to spend, particularly on infrastructure. This could also be the case since most of the nations in the area are notorious for having high levels of debt or loan servicing, and as a result, most of the money received goes towards paying off loans. According to table 4.5, nations in the subregion witnessed an increase in population of 2.535% throughout the period, with the largest growth reported being 4.716% and the lowest being 2.702%. Population is used to measure the growth experienced in a country's overall population. This demonstrates the market worth or potential of the ready market of nations in sub-Saharan Africa.

According to research on sectorial growth, the sub-Saharan African nations' GDP is mostly driven by the service sector. The service sector generates, on average, 40.241 percent of GDP. The sectors for manufacturing and agriculture came next, with scores

of 20.986 and 9.186, respectively. This is hardly surprising considering that most sub-Saharan African nations already embrace the manufacturing-driven industrialisation push. Additionally, the service sector's standard deviation score of 17.662% suggests that it is not a genuine representation of the mean values. Only agriculture had a kurtosis rating that was often closer to 3, with the remainder being leptokurtic in nature. Additionally, of the three sectors considered in this analysis, the coefficient of variation reveals that agriculture is the most distributed variable.

The research further established the association between and among the many variables used after describing all the variables' characteristics or aspects using descriptive statistics. The findings of the correlation coefficient analysis are shown in Table 4.6.

4.3.2 Correlation Co-efficient

The correlation co-efficient describes the link or relationship between and among the variables used to attain this goal. The research proceeded further to determine the link between and among the many variables used after describing the characteristics of each variable via descriptive statistics. The findings for this goal about the correlation co-efficient between the variables are shown in the following table (4.6).

Table 4. 6: Correlation Co-efficient

	IM	EX	GFCF	PD	RGDP	Inf	Gov Exp	Pop	Service	Manu	Agric	ICT
IM	**1.000**											
EX	0.670	**1.000**										
GFCF	0.396	0.422	**1.000**									
PD	0.188	0.570	0.404	**1.000**								
RGDP	-0.003	-0.015	0.022	-0.014	**1.000**							
Inf	-0.047	-0.031	-0.053	0.004	-0.042	**1.000**						
Gov Exp	0.528	0.393	0.431	0.206	-0.088	-0.063	**1.000**					
Pop	-0.180	-0.080	0.061	0.062	0.166	0.044	-0.118	**1.000**				
Service	-0.257	0.514	0.834	0.751	0.195	0.798	0.214	0.381	**1.000**			
Manu	-0.687	0.365	0.267	0.986	0.224	0.530	0.369	0.967	0.582	**1.000**		
Agric	-0.004	0.419	0.324	0.549	0.874	0.321	0.965	0.741	0.357	0.621	**1.000**	
ICT	0.211	0.335	0.845	0.452	0.124	0.302	0.631	0.114	0.215	0.459	0.687	**1.000**

Note: PD=Port Development; IM=Import; EX=Export; ICT=Adoption of Technology; GovtExp=Government Expenditure; Pop=Population; Inf=Inflation; GFCF=Gross Fixed Capital Formation; RGDP=Real Gross Domestic Product; Agric=Agriculture Sector; Service=Service Sector; Manu=Manufacturing Sector

Table 4.6 findings reveal an intriguing trend, with imports developing a significant but positive correlation with exports. This positive correlation between these factors may be due to the problem of competitive advantage, in which a country or economy focuses on producing goods and services at a relatively lower cost for export while importing those that are more expensive or require specialised knowledge. Imports likewise established a favourable link with GFCF and port development in terms of the proxies for infrastructure development, although this time, the association was marginal, with values of 0.396 and 0.188, respectively. This suggests that a nation in sub-Saharan Africa has a better likelihood of strengthening its infrastructure base the more it imports. This is true since importing products boosts economic activity because they may be sold again, and most significantly, importing products generates tariffs at the port that provide the state money. In sub-Saharan Africa, imports did, however, develop a positive and robust connection with government spending but a negative but moderate association with real gross domestic product, inflation, and population. This is because importation lowers the nation's overall productivity levels, resulting in a low GDP and a low or negative RGDP for the nation. This could be because many African administrations, particularly in Sub-Saharan Africa, are imported heavily. This further explains why imports often do not harm the economy, which high unemployment rates and low tax rates may cause. It was noted that exports exhibited a positive link with the factors of interest (GFCF and port development) while examining the relationship between exports and other variables. This indicates that commerce and infrastructure development are moving in the same direction in sub-Saharan Africa. This suggests that the growth or enhancement of infrastructure in sub-Saharan Africa serves as a conduit for export-based global commerce. Here, items are made available by the advanced ICT networks that facilitate ordering from many nations and continents. Government

spending also showed a positive correlation, albeit small; real gross domestic product, inflation, and population showed a negative correlation with these factors. This demonstrates that government spending encourages exports, which could take the form of giving subsidies to the agricultural sector to enable farmers to produce enough goods to meet the needs of the country's population and then export them to neighbouring nations or states. This demonstrates how important infrastructure development is for global commerce. Construction only exhibited a negative link with real domestic products when combined with the proxies of infrastructure development, whereas GFCF created a positive correlation with all the variables except inflation. Real domestic products also showed a negative correlation with government spending and inflation, but a positive correlation with population. It's interesting to note that government spending had a negative correlation with inflation, and that population had a negative correlation with government spending. In conclusion, it can be concluded that most of the factors are favourable for sub-Saharan African infrastructure development but not for inflation. It's interesting to note that ICT adoption, which is one of the factors influencing infrastructure development, has a positive correlation with all the other variables included in the research. Except for imports, all the variables and the service, manufacturing, and agricultural sectors developed positive relationships with each other and among themselves. Thus, the expansion of the service sector in sub-Saharan Africa inhibits the import of commodities and services.

4.3.3 Findings and Discussion

After the study has concluded with the preliminary findings of this objective through its descriptive statistics and correlation co-efficient to have an in-depth understanding of all the various employed to achieve this objective. In analysing the transmission effects of infrastructure development on international trade in sub-Saharan Africa

through the various sectors, namely, the agricultural sector, manufacturing sector and the services sector. The study first examined the various variables regarding unit root test to ascertain the stationarity of the variables employed in the study. Some of the test conducted includes Levin-Lin-Chu (LLC-stat), Breitung t-stat, Hadri Z-stat and Harris Tzavalis test. The outcome of the unit root test is presented in Table 4.7 below.

Table 4. 7: Panel Unit Root test

Variables	LLC -stat: H0: Unit root	Breitung t-stat: H0: Unit root	Hadri Z-stat: H0: No unit root	Harris Tzavalis H0: No unit root
Port Development	1.125*** (0.001)	1.024 (0.509)	34.111*** (0.000)	0.847 (0.769)
Gross Fixed Capital Formation	0.646*** (0.000)	2.194 (0.972)	18.136*** (0.000)	0.806** (0.017)
ICT Adoption	-0.405 (0.293)	0.647 (0.994)	42.270*** (0.000)	0.726*** (0.001)
Import	-0.537*** (0.000)	0.332 (0.871)	38.697*** (0.000)	0.378 (0.858)
Export	0.764 (0.937)	1.035 (0.999)	25.995*** (0.000)	0.907 (0.746)
Service Sector	-7.248*** (0.000)	-4.000 (0.499)	32.321*** (0.000)	0.407 (0.465)
Agriculture Sector	-8.157*** (0.000)	1.701 (0.567)	39.302*** (0.000)	0.396 (0.193)
Manufacturing Sector	-1.387** (0.017)	-2.683 (0.349)	43.891*** (0.000)	0.367 (0.319)
Government Expenditure	-0.311* (0.085)	4.529 (0.973)	26.002*** (0.000)	0.135** (0.026)
Population	-4.214*** (0.000)	2.162 (0.896)	49.100*** (0.000)	0.672 (0.499)
Inflation	8.125 (1.000)	-3.289 (0.101)	32.324*** (0.000)	0.125*** (0.000)
Real Gross Domestic Product	2.563 (0.912)	-0.716 (0.031)**	26.499*** (0.000)	0.486 (0.276)

Note: *, ** and *** denotes significance value of 10%, 5% and 1% (p-values)

The panel unit root test analysis results are shown in the table above (table 4.7) for the investigation. All the variables included in the study's variables were subjected to this unit root test. The null hypothesis of the research, according to which there are no unit roots in any of the used variables, forms the foundation for how the unit root test findings are to be interpreted. The Levin-Lin-Chu (LLC), Breitung, Hadri LM Stationarity, and Harris-Tzavalis panel root tests are included. Using Levin-Lin-Chu test, it was determined that the LLC may clearly reject the null hypothesis since port development and gross fixed capital creation are extremely significant and show that they are stationary. However, ICT Adoption serving as another independent variable for infrastructural development was insignificant and the study failed to reject the null hypothesis, thereby confirming the non-existence of unit root. Further, with the proxies of international trade, import showed the presence of unit root while export indicated or showed otherwise thereby failing to reject the null hypothesis for export. Interestingly, regarding the sectorial value addition proxies, all of them (manufacturing, service, and agriculture) showed stationarity properties. Concerning the controls, only government expenditure and population exhibited stationarity properties by being significant but same cannot be said of inflation and real gross domestic product as these proxies exhibited non-stationarity property. We therefore failed to reject the null hypothesis for these variables. In the nutshell, the unit root test of Levin-Lin-Chu showed that the null hypothesis was failed to be rejected by inflation, real gross domestic product, export, and ICT Adoption. This shows non-stationarity property, but the rest of the variables showed a stationarity property, therefore rejecting the null hypothesis.

Further, the study conducted the Breitung unit root test on the variables. It was uncovered that only real gross domestic product exhibited a stationarity property while

the remaining variables did not, so we fail to reject the null hypothesis for all the variables except real gross domestic product. Also, when the Hadri-Tzavalis unit root test was carried out, it was observed that all the variables in the study exhibited a stationarity property, with none indicating otherwise. This made the study reject the null hypothesis, which indicates the non-presence of unit root by accepting that here is a presence of unit root in all the variables.

The Harris Tzavlis unit root test gave mixed findings with some of the variables indicating the presence of unit root which depict stationarity while other variables also indicated or showed its non-stationarity properties. For the proxies for international trade, none of them indicated or showed a stationarity property, making the study fail to reject the null hypothesis, same result was uncovered for the various sectors in sub-Saharan Africa which was used or employed. However, with the proxies of infrastructural development, ICT Adoption and Gross Fixed Capital Formation exhibited stationarity properties but port development did not show that this variable is not stationary. The study went further to estimate the short and long run effects based on the stationarity of the variables used in the study.

After estimating the stationarity properties of the variables needed for the study in examining the short and long run effects of infrastructure development on international trade through the various selected sectors in sub-Saharan Africa. The study proceeded to estimate its effects.

It is essential to note that, the study estimated the short run and long run effects on international trade independently and separately on both proxies used in measuring international trade (imports and exports). The table below (Table 4.8) shows the presentation of the short-run and long-run effects of infrastructural development on

international trade through import in sub-Saharan Africa considering the various transmission channels or sectors in the economy.

Panel Cointegration Test

To examine the long-term relationships between infrastructure development variables, sectoral variables, and some control variables, we estimated the cointegration test for the dependent variables for international trade (exports and imports) after the study had finished the panel unit root test. The study extensively used Pedroni (2001) and Westerlund (2007) in estimating the cointegration test. The Westerlund test evaluates the applicability of the adjustment coefficient inside an error correction model framework, whereas the Pedroni test is computed using the residuals of the long-run static regression. In this study, the alternative cointegration hypothesis serves as the null hypothesis and the Pedroni and Westerlund cointegration tests are run. Since there would otherwise be no long-term connection between the variables in the study, the study infers that there is a stable long-term effect if we reject the null hypothesis. The outcomes of the cointegration test are shown in the table below (table 8).

Table 8: Cointegration Test

Cointegration Test		Import (IM)	Export (EX)
Pedroni	Panel ADF	-2.361*** (0.000)	-1.027*** (0.000)
	Panel-v	3.257*** (0.000)	3.360*** (0.000)
	Panel-t	-2.184*** (0.000)	-3.597*** (0.000)
	Panel-rho	-2.913*** (0.000)	-2.702*** (0.001)
Westerlund	G_a	-1.891*** (0.000)	-1.098*** (0.000)
	G_t	-3.804*** (0.000)	-2.644*** (0.000)
	P_t	-2.517*** (0.000)	-3.139*** (0.000)
	P_a	-3.800*** (0.000)	-3.249*** (0.000)

Note: *, **, *** and ( ) denotes 10% significant level, 5% significant level, 1% significant level and p-values respectively.

The cointegration values for the various tests performed on the variables to determine their eligibility for the assessment of long-term effects are shown in the table above (table 8). All four tests for Westerlund cointegration demonstrated strong evidence for the presence of cointegration between international trade, infrastructural development,

and the various sectors (Agriculture, Services, and Manufacturing in addition to some of the control variables) regarding the results of the Westerlund test with both measures of international trade. The null hypothesis was ruled out by all four tests, according to the recorded p-values, with all the variables exhibiting a significant level of 1%, which indicates a highly significant output. Furthermore, the results of Pedroni tests, on the other hand, were consistent with those of the Westerlund test since there was evidence of cointegration for both international trade variables (import and export). Evidently, all four tests performed using the Pedroni method rejected the null hypothesis, supporting the idea that international trade, infrastructure development, and diverse industries in Africa share a long-term nexus. In conclusion, the results of the Westerlund and Pedroni cointegration tests demonstrated that the factors affecting international trade in sub-Saharan Africa shared stochastic tendencies that indicate a long-run path. Based on the cointegration test results, we estimate the series' short and long run relationships to investigate the impacts of infrastructure development and sectorial value adds on international trade in sub-Saharan Africa.

Sectoral value additions, Infrastructural Development, and International Trade

Table 4.8: Sectoral value additions, Infrastructural development, and Import

Variables	Dependent variable – Import					
	Independent variable – Infrastructural Development					
	ICT	GFCF	PD	ICT	GFCF	PD
Short-Run						
International Trade (Import)	0.247* (0.055)	0.710* (0.076)	0.004 (0.854)	-0.006 (0.900)	0.702 (0.395)	0.045 (0.188)
Services	0.724 (0.910)	-0.834*** (0.000)	-0.534*** (0.000)	-	-0.223*** (0.009)	-
Manufacturing	-0.197*** (0.004)	0.387*** (0.0020)	0.367* (0.021)	1.020*** (0.005)	0.169*** (0.007)	1.016** (0.011)
Agriculture	-0.398** (0.011)	-0.014*** (0.001)	-0.327** (0.018)	-0.880 (0.710)	-	-0.078 (0.902)
Long-Run						
International Trade (Import)	0.001* (0.095)	0.002 (0.297)	0.012** (0.024)	0.008 (0.537)	-0.402* (0.065)	0.122** (0.022)

Service	0.212* (0.051)	0.301** (0.031)	1.611* (0.084)	-	-0.005 (0.239)	-
Manufacturing	1.503*** (0.000)	1.223*** (0.000)	0.172*** (0.000)	0.524*** (0.000)	0.619*** (0.001)	1.182*** (0.000)
Agriculture	0.703*** (0.001)	0.613*** (0.001)	0.692*** (0.001)	0.081** (0.030)	-	0.472*** (0.001)
Error Correction	-0.209*** (0.000)	-0.281*** (0.000)	-0.242*** (0.000)	-0.235*** (0.000)	-0.294*** (0.000)	0.228** (0.024)
Constant	1.980* (0.066)	1.725** (0.034)	1.418* (0.052)	-0.429 (0.145)	-0.231 (0.732)	0.927 (0.204)
Diagnostics						
Log Likelihood	-138.986	-155.284	-182.424	-224.157	-244.951	-256.684
Number of Groups	43	43	43	43	43	43

Note: *, ** and *** denotes significance value of 10%, 5% and 1% (p-values): PD=Port Development; ICT=Adoption of Technology; GFCF=Gross Fixed Capital Formation.

The results from table 4.8 indicate the impacts of infrastructural development and the sectoral value additions and their impact on international trade in their short-run (in the interim where the factors of production cannot be varied) and long-run (Where all the factors of production can be varied) implications. In the study, infrastructural development is being proxied by port development, gross fixed capital formation and Information Communication Technology (ICT) Adoption while international trade serving as the dependent variable is being proxied by import. It was seen that infrastructural positively impacted international trade in the short run, with port development not being significant. However, ICT Adoption and gross fixed capital formation established a significant impact of 10%. This shows that, in the short run, infrastructural development promotes international trade through the adoption of information communication technology and overall infrastructure development in an economy through gross fixed capital formation. This is where the introduction of digitalization (through ICT) makes it easier in the interim for individuals, businesses, and governments to import or order things that are not currently available in their country. Nevertheless, ICT adoption maintained its positive impact in the long run as well. This means that, ICT Adoption impact international trade trough import positively in both short and long run. In both instances, the positive impact was significant at 10%. Further, gross fixed capital formation which served as another independent variable showed positive impact with international trade in both situations was only significant in short run period. This means that, development of infrastructure through the construction of goods and durable roads, good transport system among others spurs international trade in sub-Saharan Africa. With port development, it was revealed that, though its impact on international trade is positive, it is highly significant at 5% in the long run. This is where in the long run, after the various ports have been developed,

they will have enough capacity to handle all the demands of the citizen through their importation. This helps improve international trade in the long run. The study did a sensitivity analysis by dropping some of the variables to know its long and short run impact as well. The results show that, ICT adoption impacted negatively on international trade in the short run but positively impacted in the long run. Gross fixed capital formation impacted significantly in the long run at 10%. Same was noticed for port development as it impacted positively and significantly in the long run. This finding is consistent with Liu (2017) who uncovered that port development spurs international trade bu reducing transaction cost. Also, Yang (2018), revealed that infrastructure-trade nexus is positive in the long run. This means that, the development of the various ports in sub-Saharan Africa and the adoption of ICT spurs international trade in the long run. Based on this, governments must take a critical look at these two variables. A perfect example is the removal of benchmark quotations at the Ghanaian harbor which has made import duties expensive in the interim, this can be reduced in the long run by government introducing policies that will mitigate these short run effects.

On the various sectors, it was observed that international trade (import) through the service sector is positive and insignificant in the short run when infrastructural development is proxied with ICT Adoption. This is because most of the services requires the use of technology to be able to deliver, so the service sector promoting international trade through ICT Adoption is a true reflection of the current happenings and it maintained its positive impact it the long run at a significance level of 10%. This means that, as people understand and “buy into” the ICT Adoption idea, activities in the service sector will improve trade in both short and long run situations. Also, service sector established a negative but highly significant impact through infrastructural

development (gross fixed capital formation and port development) on international trade in sub-Saharan Africa. These impacts are said to be significant at 1%. This is where proper road networks and a developed port make trade possible, especially when goods are imported into the country. However, the negative impact in the short run changed to a positive and significant impact in the long run. This means that, in the long run, the intended benefits of improving trade in sub-Saharan Africa using infrastructural development can be realized in the long run but not the short run as the short run discourages imports. So, depending on the country's aims, it can tilt its policies to achieve the long or short-run effects. In the sensitivity analysis, the study regressed only with gross fixed capital formation, showing negative impact in both the short and long run. This shows that, to reduce importation of goods into a country through the service sector especially in sub-Saharan Africa then there is the need for governments to have a look at the gross fixed capital formation components.

Furthermore, on the manufacturing sector or industry, it was observed that international trade through infrastructural development impact positively and significantly when proxied with gross fixed capital formation and port development but negative in the short run when proxied with ICT Adoption. This means that the manufacturing sector spurs trade through importation of goods especially raw materials, for production. However, all the proxies of infrastructural development impacted positively and highly significantly in the long run. This means that infrastructural development through the manufacturing sector promotes international trade around import. However, in the sensitivity analysis, the manufacturing sector promotes trade in both short and long run. This means that, the growth of the manufacturing sector is critical for international trade through imports.

Moreover, the largest sector in sub-Saharan Africa and the African continent is known to be the agricultural sector. The Agricultural sector is the highest, especially in terms of job creation and unemployment reduction. With regards to the impact of infrastructural development on international trade through the agricultural sector, it was keenly observed that agricultural sector established negative and highly significant impact on international trade through the various variables of infrastructural development in the short run. This means that, agriculture is a disincentive for international trade in sub-Saharan Africa in the short run. This further means that, agriculture will prevent the imports of goods and services needed for growth of the sector and this is because, it won't give the needed incentive immediately as it takes time for it to recoup your investment. It is therefore, not surprising that agricultural sector promotes international trade positively. This means that, in the long run, the needed impact can be accrued from the investment made. The sensitivity analysis still maintained negative impacts in the short run and positive impact in the long run. This also means that agriculture as a channel to promote trade is useful in the long run.

After the study has examined the effects of infrastructural development on international trade specifically on imports through the various economic sectors acting as a transmission channel, the study explores the effects of infrastructure development on the other proxy of international trade (export). The table below (Table 4.9), shows a presentation of the results uncovered.

Sectoral value additions, Infrastructure, and International Trade

Table 4. 9: Sectoral value additions, Infrastructure, and Export

Variable	Dependent Variable – Export					
	Independent Variable – Infrastructural Development					
	ICT	GFCF	PD	ICT	GFCF	PD
Short Run						
International Trade (Export)	0.040*** (0.000)	-0.410 (0.815)	-0.071 (0.158)	-0.046 (0.521)	-0.027 (0.124)	-0.460*** (0.000)
Services	0.007*** (0.000)	-0.031 (0.724)	-0.125 (0.540)	-	0.073 (0.664)	-0.011 (0.158)
Manufacturing	0.504* (0.073)	0.248*** (0.000)	0.052 (0.418)	0.155 (0.195)	-	0.791 (0.465)
Agriculture	0.410* (0.097)	0.017** (0.024)	0.095 (0.864)	0.480 (0.864)	-0.540 (0.386)	-
Long Run						
International Trade (Export)	0.073** (0.022)	0.663*** (0.001)	0.403*** (0.001)	-0.640 (0.981)	1.102*** (0.000)	0.271*** (0.000)
Services	0.580*	-0.510	-0.054***	-	-0.684**	-0.600

	(0.067)	(0.617)	(0.000)		(0.031)	(0.898)
Manufacturing	0.311***	0.640***	0.881**	0.916***	-	0.843***
	(0.000)	(0.002)	(0.043)	(0.001)		(0.000)
Agriculture	0.811*	0.541**	-0.904**	0.480	-0.964**	-
	(0.094)	(0.034)	(0.049)	(0.314)	(0.077)	
Error Correction	-0.164***	-0.238***	-0.214***	-0.189***	-0.190***	-0.260***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	1.724**	0.169*	-1.362***	1.817**	-5.492***	0.931
	(0.024)	(0.081)	(0.001)	(0.063)	(0.000)	(0.748)
Diagnostics						
Log Likelihood	-324.510	-318.623	-329.881	-330.555	-337.857	-322.697
Number of Groups	43	43	43	43	43	43

Note: *, ** and *** denotes significance value of 10%, 5% and 1% (p-values); PD=Port Development; ICT=Adoption of Technology; GFCF=Gross Fixed Capital Formation.

From the table above (Table 4.9), it was realized that apart from ICT Adoption, all other variables for infrastructural development showed a negative impact in the short run. This means that, countries in sub-Saharan Africa can get the needed benefits from international trade especially export if they invest heavily in technology as this is likely help in improving exports. This is because, we are in an era of technological advancement and technology has helped developed economies to improve trade especially in export through the ability of those outside the jurisdiction of the country in question to order goods and services without necessarily travelling to the country. This makes it easier for the transportation cost to be saved and used to import more goods. This improves trade in other countries. This positive impact is significant at 1% in the short run. Same negative results were experienced for export in the short run when sensitivity analysis was done by dropping some of the variables for infrastructural development. However, in the long run situation, it was revealed that all the variables for infrastructural development, namely, ICT Adoption, port development and gross fixed capital formation exhibited positive effects on international trade. This means that, in the long run, infrastructural development can improve exports in sub-Saharan Africa and as such much attention should be given to it for their infrastructural base to develop. This is where when there is good road, strong internet connection, developed ports with less cumbersome procedures make it time convenient for goods to be shipped out. More exports than imports improve the balance of payment deficit of a country. With, the sensitivity analysis, it was seen that ICT Adoption inhibits export trade in the long run and this is because most of the citizens might not have been accustomed to the kind of sophisticated technologies in place, making it difficult for them to acquire the needed benefits. All the positive impacts in the long run are statistically significant. These finings are in agreement with similar findings with Rehnam (2020) who

concluded that ICT infrastructure has positive and significant impact on international trade. This makes infrastructural development crucial to international trade in developing economies especially in sub-Saharan Africa in the face of numerous trade agreements.

With the transmission channels, it was realized that the service sector saw a positive impact in the short run through ICT Adoption regarding trade (export). This is where there is a tendency for export to increase if countries in sub-Saharan Africa invest in technology. This is because services are mostly not tangible goods that can be touched, most of which are done through a medium. When technologies are abundant in a particular economy, it makes it possible for citizens to take on remote jobs in other countries, thereby exporting their services. This positive impact in the short run is highly significant at 1%. The sensitivity analysis saw gross fixed capital formation to be positive in the short run. In the long run however, ICT Adoption maintained its positive and significant impact and its impact in an economy is already stated above, but gross fixed capital formation and port development expressed a negative impact, with port development being significant at all conventional levels. This means that, in the long run, developing the ports in sub-Saharan African countries a disincentive for exports especially in the service sector. Also, Chen (2005) in his investigation of how infrastructure development affects the service sector discovered that infrastructure development impact positively on services through reduction in the cost of trade communications, and expansion of cross-border trade in services.

Further in the manufacturing sector, it was revealed through the study that ICT Adoption, gross fixed capital formation and port development impact the positively through export with ICT Adoption and gross fixed capital formation being significant at 10% and 1% respectively. This means that the manufacturing sectors will give

countries in sub-Saharan Africa the immediate benefits of international trade (export) when the infrastructural based is developed. This is because, the manufacturing sector is known as the centre of industrial hub and as such when goods and services are produced in larger quantities, they will be able to export into foreign markets especially now the African continental free trade agreement is in force. Same outcome was established in the long run but in this situation all the variables for infrastructural development are highly significant at 1%. This further imposes the crucial nature of the manufacturing sector to sub-Saharan African countries and as a key variable in reducing the balance of payment deficits experienced on this part of the continent. This shows that, with the requisite development in the infrastructure, the manufacturing sector can develop and hence promoting trade in both short and long run. This is key to growth and development of sub-Saharan Africa.

Moreover, the agricultural sector also showed a promising sign in facilitating exports of goods and services in sub-Saharan Africa. This is not surprising because agriculture is the backbone of many if not all countries in sub-Saharan Africa and Africa as a whole. From the table above (Table 4.5), it was seen that agriculture showed positive and significant effects with international trade with ICT Adoption and gross fixed capital formation with a significant value of 10% and 5% respectively. This is true in the sense that, when governments can provide good roads for the transportation of agricultural products especially in rural areas where the practicing of agriculture is at its peak. This helps reduce wastage of goods in the economy especially when it comes to perishable goods. This will make a lot of goods available in the system for consumption and exports. In the long run effects, the same positive and significant impact was established for ICT Adoption and gross fixed capital formation. Interestingly, port development showed a negative and significant effects in the long run. This is surprising because the

development of ports plays a major role in the exports of goods and services in every country or economy. Some of the reasons for these negative effects could be policies geared towards making the port activities less expensive for exporters to encourage individuals to export goods and services in that country in question.

4.4 Objective Three: The threshold effects of infrastructural development on international trade in sub-Saharan Africa.

This is the third objective of the study. After examining the short run and long run effects of infrastructure development on international trade, the study went further to examine if infrastructure-trade nexus in sub-Saharan Africa is threshold specific. This where the study determines if over development of infrastructure in sub-Saharan Africa promotes or hurts international trade in this region.

4.4.1 Preliminary Findings

This section of the chapter provides details into the initial discussions of the study, which comprises the descriptive statistics and correlation co-efficient of all the variables employed to achieve this objective.

4.4.1.1 Descriptive Statistics

This is an aspect of the preliminary findings. The descriptive statistic of this objective describes the behavior of all the variables adopted to achieve this objective. The descriptive statistics contains the mean, standard deviation, maximum, minimum, skewness, kurtosis, co-efficient of variation, and observations, among others. Table 4.10 contains the descriptive statistics of the variables for the period 1985 to 2020.

Table 4. 10: Description Statistics

	IM	EX	ICT	GFCF	PD	RGDP	Inf	Gov Exp	Pop
Mean	34.032	25.391	3.056	17.996	22.313	3.808	37.139	12.969	2.535
Std. Dev	22.954	18.927	5.953	11.512	13.711	7.049	631.864	8.115	1.084
Max	42.343	34.695	14.110	23.969	28.152	6.247	248.120	22.009	4.716
CV	0.674	0.745	1.724	0.640	0.614	1.851	17.013	0.626	0.428
Skewness	2.045	1.070	5.953	0.689	1.064	6.156	34.729	0.734	-1.434
Kurtosis	14.312	4.254	16.499	5.331	5.155	133.074	1290.669	5.301	12.972

Note: PD=Port Development; IM=Import; EX=Export; ICT=ICT Infrastructure; Gov Exp=Government Expenditure; Pop=Population; Inf=Inflation; GFCF=Gross Fixed Capital Formation; RGDP=Real Gross Domestic Product; Std. Dev=Standard Deviation; Min=Minimum; Max=Maximum; CV=Coefficient of Variation.

Since the average import and export values recorded for the period are 34.032 percentage of GDP and 25.391 percentage of GDP, respectively, it can be seen from the table above (table 4.10) that nations in Sub-Saharan Africa participate more in the importing of commodities than the exportation of them. This demonstrates that sub-Saharan Africa imports most of its necessities. The fact that import has a standard deviation of 22.951 indicates that its values are more erratic than those for export (18.927). Given that Sub-Saharan African nations are notorious for importing more than they export, the highest import value for the period was 42.343 percentage of GDP. This indicates that at one point, about half of the region's GDP was accounted for by goods imported into sub-Saharan Africa. However, both variables are leptokurtic in character and skewed to the right with values of 2.045 and 1.070 for import and export, respectively. As a result, sub-Saharan African nations might be considered an imported part of Africa. It was discovered that GFCF had an average of 17.996% with a standard deviation of 11.512 when it came to the independent variables (GFCF, port development, and ICT adoption). This indicates that the average investment in infrastructure development in this area via GFCF is 17.996% of GDP, whereas the average investment in port expansion is 22.313 % of GDP and the average investment in ICT adoption is just 3.05 % of GDP. This indicates that a significant portion of investments made in sub-Saharan Africa are used to develop and expand the many ports located on this side of the continent. When infrastructure development is considered, ICT adoption is considered as being the least. Additionally, the port development exhibits a kurtosis value of 5.155, indicating leptokurtic behaviour with all its values being favourably skewed (1.064). This demonstrates that Sub-Saharan Africa has made significant investments in infrastructure, but more must be done, particularly regarding ICT adoption and development nationally, particularly at the region's many ports.

RGDP represents the Sub-Saharan region's actual gross domestic products. It shows how they have grown and changed. It was discovered that Sub-Saharan African nations only had an average 3.808% growth in their GDP from 1985 to 2020. It is interesting to note that it reached a point when certain nations experienced negative growth, as shown by the minimum figure of -4.666%. This indicates that certain Sub-Saharan African nations "fell back" in developing their own economies. These eras could be connected to the political unrest seen in the early stages of colonisation. However, the highest rate of growth across all economies is just 6.247%, which is not a strong indicator of growth across nations. This demonstrates that the RGDP of nations in sub-Saharan Africa is low, which may be related to the low level of economic activity in this region because of insufficient trade volumes. Additionally, it was found that nations in Sub-Saharan Africa are known to face large levels of inflation as the smallest value was 37.139% and the highest was an astounding 248.120%. Government spending, inflation, and population served as the control variables. This further indicates that inflation is a specific problem among Sub-Saharan African nations. Finding out that the government spends just 12.96% of the GDP of all income generated is startling and further supports the infrastructure deficit. This implies further that many governments in sub-Saharan Africa want additional income streams to have adequate money to spend, particularly on infrastructure. This could also be the case since most of the nations in the area are notorious for having high levels of debt or loan servicing, and as a result, most of the money received goes towards paying off loans. Population growth is measured by the number of people in each country overall. Accordingly, nations in sub-region in Table 10 witnessed population increase of 2.535% throughout the period, with the largest growth reported being 4.716% and the lowest growth being 2.702%.

This demonstrates the potential of sub-Saharan African nations in terms of market value or ready markets.

The research proceeded further to determine the link between and among the many variables used after describing all the variables' characteristics or attributes via descriptive statistics. The findings of the correlation coefficient analysis are shown in Table 4.11 below.

4.4.1.2 Correlation Co-efficient

The relationship between and among the study's variables is dealt with using correlation. The research proceeded further to determine the association between and among the many variables used after describing the characteristics of each variable using the descriptive statistic. The findings that were discovered are shown in Table 4.11 below.

Table 4. 11: Correlation Co-efficient

	IM	EX	GFCF	PD	RGDP	Inf	Gov Exp	Pop	ICT
IM	**1.000**								
EX	0.670	**1.000**							
GFCF	0.396	0.422	**1.000**						
PD	0.188	0.570	0.404	**1.000**					
RGDP	-0.003	-0.015	0.022	-0.014	**1.000**				
Inf	-0.047	-0.031	-0.053	0.004	-0.042	**1.000**			
Gov Exp	0.528	0.393	0.431	0.206	-0.088	-0.063	**1.000**		
Pop	-0.180	-0.080	0.061	0.062	0.166	0.044	-0.118	**1.000**	
ICT Adoption	0.211	0.335	0.845	0.452	0.124	0.302	0.631	0.114	**1.000**

Note: PD=Port Development; IM=Import; EX=Export; ICT=Adoption of Technology; Gov Exp=Government Expenditure; Pop=Population; Inf=Inflation; GFCF=Gross Fixed Capital Formation; RGDP=Real Gross Domestic Product

Table 4.11 findings reveal an intriguing trend, with import and export developing a strong yet positive relationship. The issue of competitive advantage, where an economy or a country concentrates on goods and services that they can produce at a relatively lower cost for export but import those they are at a disadvantage of the production chain in terms of cost and expertise, may be the cause of this positive association between these variables. Import also developed a favourable relationship with GFCF and port development as proxy for infrastructure development, however this relationship is only moderately strong, with values of 0.396 and 0.188, respectively. This suggests that a nation in Sub-Saharan Africa has a better possibility of developing its infrastructure base as importation increases and this is true since importing products boosts economic activity because they may be sold again and, most significantly, because they are subject to duties at the port, which bring in revenue for the government. In Sub-Saharan Africa, imports were shown to have a negative but moderate relationship with real GDP, inflation, and population, but a positive and robust relationship with government spending. This is because importation of products lowers the nation's overall productivity levels, resulting in a low GDP and a low or negative RGDP. This may be a result of the significant importation carried out by African countries, particularly in Sub-Saharan Africa. It goes on to explain that imports often affect the economy, which may result in high unemployment rates and low taxes. Regarding the correlation between export and other factors, it was found that exports had a favourable connection with the relevant independent variables such as gross fixed capital formation and port development. This indicates that commerce and infrastructure development are moving in the same direction in Sub-Saharan Africa. This further suggests that the growth or enhancement of the infrastructure in sub-Saharan Africa serves as a conduit for export-based global trade. The ability to order from other countries and continents is made

feasible by the developing ICT networks in this area. While real gross domestic product, inflation, and population showed negative correlations with these factors, there was also a positive link with government spending, even if this correlation was modest. This demonstrates that government spending encourages exports, which could take the form of giving subsidies to the agricultural industry to help farmers produce enough goods to meet domestic demand before exporting to neighbouring nations or states. This demonstrates how important infrastructure development is to world trade. When it comes to the proxies for infrastructure development, gross fixed capital formation created a positive link with every factor save inflation, while construction only established a negative association with real domestic product. Real domestic product also showed a negative correlation with government spending and inflation, but a positive correlation with population. It's interesting to see that government spending established a negative connection with population, and that relationship was mirrored by inflation. In summary, it can be concluded that although most of the factors are favourable for Sub-Saharan Africa's infrastructure development, inflation is not. ICT adoption, a technological progress that functioned as one of the factors for infrastructure development, interestingly formed a positive link with every other variable included in the research.

4.4.2 Results and Discussions

The threshold impacts of infrastructure development on global trade in sub-Saharan Africa are examined in this section of the research. In this section, the research focused on two key issues: determining if a threshold existed and estimating a threshold between different variables. The research initially evaluated for the presence of threshold on all the variables included in the study before proceeding to estimate the threshold relationship between infrastructure development and trade. The presence of threshold

was investigated across a total of seven key variables. These proxies included controls variables (population, inflation, Government Expenditure and Real Gross Domestic Product), and independent variables (gross fixed capital formation, port development, and adoption of ICT) used in the study.

The table below (Table 12) shows the results uncovered through testing the existence of threshold, which is known as the first and basic requirement if any study wants to examine the threshold estimation effect.

Table 4. 12: Testing for the existence of threshold in infrastructure development and international trade nexus

Variables	International Trade					
	Threshold Variable: I**mport**			Threshold Variable: **Export**		
	LM-Test for no threshold	Threshold Estimate	Bootstrap p-value	LM-Test for no threshold	Threshold Estimate	Bootstrap p-value
Gross Fixed Capital Formation	25.026***	31.010%	0.001	22.941***	11.552%	0.000
Port Development	30.227***	56.231%	0.000	9.887***	17.371%	0.002
ICT Adoption	28.079**	44.694%	0.011	12.024*	34.301%	0.064
Population	32.414	16.406%	0.131	26.415	8.170%	0.229
Real GDP	15.002**	35.009%	0.021	21.386***	51.769%	0.000
Government Expenditure	47.946***	22.390%	0.000	18.863***	21.710%	0.000
Inflation	19.015*	28.016	0.092	28.190	17.376%	0.418

Note: *, ** and *** denotes significance value of 10%, 5% and 1% (p-values)

From the table above (4.12), it was reviewed that all the proxies for infrastructure development established a non-linear relationship with one of the international trade variables, import. This means that, all the variables of infrastructure development (Gross domestic product, Port Development, and ICT Adoption) exhibit the existence of threshold properties and thus, the threshold estimation can be done with regards to imports. This is where their threshold existence is derived from their Bootstrap p-value which indicates significance. For gross fixed capital formation and Port Development, it showed a 1% significant level (thus significant at all conversional levels), and ICT Adoption is significant at 5%. Their p-values are 0.000, 0.001 and 0.011 for Port Development, Gross fixed capital formation and ICT Adoption respectively. Furthermore, two control variables exhibited threshold properties while the remaining two did not. The two control variables that exhibited threshold properties when tested against international trade through import were Real Gross Domestic Product inflation and Government Expenditure, while population did not meet the threshold testing. Population had threshold testing p-value of more than 10% hence no threshold estimation will be done on them. In all, six (6) variables exhibited threshold properties out of the seven (7) employed in relation to import as a proxy to international trade. Moreover, regarding the other proxy for international trade (export), it was revealed that all the proxies for infrastructure development in sub-Saharan Africa showed the presence of threshold property in them. This means the study can estimate the threshold effect of infrastructure development on international trade (export). This was seen in the p-values of the variables which were 10%, 1% and 1%, respectively for ICT Adoption, Port development and gross fixed capital formation. This further shows that the variables or proxies of infrastructure development is perfect for estimating the threshold value for export. A careful look at the controls adopted shows that, inflation

and population did not establish the presence of threshold with export but government expenditure and real gross domestic product with a significance level of 1% showed the presence of threshold.

In a nutshell, it was revealed that gross fixed capital formation, port development, ICT Adoption, real gross domestic product, and government expenditure exhibited threshold properties in both proxies of international trade (Export and Import). Except for inflation which established threshold property with import only.

After the study tested for the existence of a threshold, the study proceeded to estimate the threshold effects for significant variables during the threshold testing phase. The table (table 4.13) below shows the results from the estimation.

Table 4. 13: Threshold Estimation Effects in Sub-Sahara Africa

Variable	International Trade					
	Linear Model: Export			Linear Model: Import		
	Global OLS without threshold	Regime 1 $[q \leq \eta]$	Regime 2 $[q \leq \eta]$	Global OLS without threshold	Regime 1 $[q \leq \eta]$	Regime 2 $[q \leq \eta]$
	Gross Fixed Capital Formation (GFCF)					
Gross Fixed Capital Formation (GFCF)	0.053*** (0.001)	0.243* (0.081)	-0.137** (0.048)	0.036** (0.012)	0.855** (0.032)	-0.021* (0.074)
Intercept	18.124	22.753	26.362	22.453	9.187	22.927
Threshold Estimate	7.368%			5.965%		
95% Confidence Interval	(7.368%-79.346%)			(5.965%-9.963%)		
Observation	1548	516	1032	1548	612	936
Joint R-Square	0.340			0.418		
R-Squared		0.005	0.072		0.034	0.022
Heteroskedasticity	0.198			0.025		
Port Development (PD)						
Port Development (PD)	0.054*** (0.001)	0.023 (0.034)	-0.059** (0.015)	0.043** (0.021)	-0.032 (0.917)	0.058** (0.016)
Intercept	19.540	19.830	30.797	24.560	17.372	19.783
Threshold Estimate	55.053%			22.743%		

95% Confident Interval	(51.724%-96.756%)			(0%-134.714%)		
Observation	1548	824	724	1548	651	897
Joint R-Square	0.220			0.111		
R-Squared		0.031	0.341		0.030	0.264
Heteroskedasticity	0.021			0.009		
ICT Adoption (ICT)						
ICT Adoption (ICT)	0.041*** (0.003)	-0.007** (0.014)	0.012** (0.043)	0.093* (0.087)	0.086* (0.077)	-0.031** (0.032)
Intercept	18.769	17.343	-13.096	22.310	20.094	
Threshold Estimate	77.003%			51.425		
95% Confident Interval	(9.752%-88.270%)			(11.283%-89.148%)		
Observation	1548	559	989	1548	701	847
Joint R-Square	0.379			0.261		
R-Square		0.031	0.028		0.033	0.038
Heteroskedasticity	0.007			0.005		
Inflation (Inf)						
Inflation (Inf)	0.059** (0.035)	0.731 (0.187)	0.225* (0.066)			
Intercept	21.544	21.153	17.824			
Threshold Estimate	8.908%					

95% Confident Interval	(8.414%-9.216%)					
Observation	1548	989	559			
Joint R-Square	0.038					
R-Squared		0.101	0.128			
Heteroskedasticity	0.476					
Government Expenditure (Gov Exp)						
Government Expenditure (Gov Exp)	0.003* (0.088)	0.017 (0.310)	0.097 (0.119)	0.061** (0.024)	0.241* (0.060)	0.025** (0.046)
Intercept	25.097	19.117	16.098	24.630	14.683	19.350
Threshold Estimate	58.286%			71.617%		
95% Confident Interval	(34.209%-91.753%)			(25.984%-92.027%)		
Observation	1548	687	861	1548	555	993
Joint R-Square	0.077			0.071		
R-Squared		0.042	0.036		0.011	0.013
Heteroskedasticity	0.000			0.000		
Real GDP (RGDP)						
Real GDP (RGDP)	-0.012 (0.087)	-0.415* (0.078)	0.702 (0.316)	0.114 (0.124)	5.827 (0.231)	0.561*** (0.004)
Intercept	20.674	22.849	26.677	21.758	25.903	15.355
Threshold Estimate	19.390%			6.123%		

95% Confident Interval	(14.649%-24.763%)			(3.321%-9.158%)		
Observation	1548	861	687	1548	411	1137
Joint R-Square	0.199			0.160		
R-Squared		0.130	0.005		0.235	0.081
Heteroskedasticity	0.014			0.966		

Note: *, ** and *** denotes significance value of 10%, 5% and 1% (p-values)

From the table above (Table 4.13), it was revealed that the threshold effect of infrastructure development (Gross fixed capital formation) and international trade (export) was seen to have expressed an inverted U-shaped. This means that, though there is the need for infrastructure development in sub-Saharan Africa but any development exceeding the threshold estimate of 7.368% will tend to hurt export that is, countries sub-Saharan Africa's ability to enter foreign markets which is one of the main reasons why the establishment of AfCFTA (Africa Continental Free Trade Agreement). This could be because monies used for the infrastructure development in this part of the globe are mostly loans the country in question must pay with interest. When this happens, companies tend to be taxed or levied to pay for such interests thereby increasing their cost of production making it difficult for them to export as they must export at a higher price than their competitors. Further, for countries in sub-Saharan Africa to gain the intended benefits from international trade through infrastructure development, they need not to develop their infrastructure above the threshold point or estimate even when the infrastructure development is dependent on loans. The impact of gross fixed capital formation on export is slightly significant at 10% and 5% in both regime 1 and 2 respectively. Moreover, when gross fixed capital

formation was estimated against import, the other measure of international trade. It was seen that gross fixed capital formation still maintains its invented U-shaped on international trade. This is where any infrastructure development above the estimated threshold of 5.965 impede imports. This further means that infrastructure development below the threshold estimates spur import. However, in every economy, there is the need for countries to limit its imports and increase its export to gain a favourable balance of payment deficits. This could be where governments levied imported goods making it expensive for the proceeds to be used to engage in infrastructure development. The threshold effects in both regimes 1 and 2 are significant at 5% and 10% respectively. In the nutshell, the threshold effect of gross fixed capital formation on all the proxies of international trade is U-shaped. That, it is economically good to operate below the threshold estimate for the impact to be gained especially when it comes to exports.

Also, the study estimated the threshold effect of infrastructure development (Port development) on international trade (import and export). From the table above (Table 4.13) it was seen that port development established an inverted U-shaped relationship and effect with exports. This is where, developing the various ports through expansion and its networks becomes a disincentive for export beyond the estimated threshold of 55.053%. However, the threshold effect is only significant at 5% in regime 2. This is because, developing and expanding the various ports will have to be levied on the citizens through the various companies in the form of taxes and these taxes increase the cost of the good in the long run. This makes it quite difficult of individuals to export. However, when the threshold effect was exerted on imports, it revealed a U-shaped effect. This means that, infrastructure developing through port expansion and improve is only incentive to import when it is done above the threshold value of 22.743% and a

disincentive to import when operated below the threshold estimate. This is a critical thing to be done because, every country cannot do without imports and more imports distort the balance of payment mechanisms making imports crucial in our economy especially in sub-Saharan Africa. Since more imports most often than not, hurt the economy, there is the need for countries in sub-Saharan Africa to operate below the threshold estimate of 22.743% because at that point, port development hurts importation. In summary, it was seen that, port development established a U-shaped and invented U-shape with export and import respectively. This means that, depending on the country's priorities, port development is crucial towards international trade in sub-Saharan Africa.

Further, the study once again estimated the threshold effects of ICT Adoption on international trade. Since we are in an era of technology and almost everything is being digitalized, there is the need for the study to know the effects that ICT Adoption has on international trade, especially in sub-Saharan Africa. From the findings, it was revealed that ICT Adoption established a U-shaped with export. This is a good thing because almost every country wants to export more and the adoption of ICT has shown that, that is the way to go. However, for the intended benefits to be gained from ICT Adoption in relation to export, countries need to develop infrastructure above the estimated threshold of 77.003%. this further means that, operating below the estimated threshold is a disincentive for international trade especially exports. Also, it was seen that, the threshold effects of both regime 1 and regime 2 are significant at 5%. This means that, the U-shaped relationship established is crucial in terms of trade. Therefore, countries in sub-Saharan Africa should operate about the estimated threshold to increase export. Interestingly, when the threshold effect of ICT Adoption was estimated against another variable of international trade (import), it established an invented U-Shaped

relationship. This means that, over adoption of ICT in sub-Saharan Africa is bad as it hurts imports. Also, it means that, operating above the estimated threshold point of 51.425% becomes a bad decision for imports as negative returns will be realized. This could be an incentive of reducing the quantity of imported goods in an economy especially in sub-Saharan Africa with the aim of maintaining a favourable balance of payment. When imports are higher than exports, countries in sub-Saharan Africa can operate above the estimated threshold to mitigate some of the impacts. Moreover, in regime 1, the ICT Adoption established a slightly significant effect with import which is at 10% and at 5% in regime 2. In the nutshell, it was seen that, ICT Adoption established a U-shaped and invented U-shape with export and import respectively. This means that, depending on the aims and aspirations of the country, ICT development is key towards international trade in sub-Saharan Africa either by improving exports and reducing imports or improving imports and reducing exports.

Moreover, aside from the variables used to estimate the threshold effects of infrastructure development and international trade, the study further introduced macroeconomic indicators crucial in every economy. These macroeconomic indicators include but not limited to inflation, government expenditure and real gross domestic product. It is worthy to note, inflation only established threshold presence with export only. Based on this, the estimated threshold of inflation on international trade will be estimated with export to the neglect of import. From the table above (table 4.13), it was seen that inflation was only significant at 10% in regime 2 only. This means that inflation is not good in many ways but if it is operated above the threshold of 8.908%, the needed impact when it comes to export will be attained. Regarding this, there is the need for countries in sub-Saharan Africa to operate above the established threshold whiles providing efforts to mitigate its negative impacts.

Additionally, government expenditure is key in every economy especially in sub-Saharan Africa. This is because the government is the highest spender in every economy in sub-Saharan Africa and Africa since a lot is expected of them. This makes government spending crucial in every economy. Regarding the threshold effect of government expenditure on international trade. It was seen that the impact with export was insignificant hence it will not be discussed. However, when estimated against import, it showed positive and significant relation or effects in both regime 1 and regime 2. Regime 1 established a significance level of 10% and 5% for regime 2. The study further estimated the threshold effect of real domestic product and international trade. Real domestic product is an inflation-adjusted measure that reflects the value of all goods and services produced by a country or an economy in a given period, mostly one year. It was revealed that, real gross domestic product established a U-shaped relationship with international trade, specifically with exports. This is where it is advisable for goods to be produced above the estimated threshold of 19.390% for them to be exported because operating above the threshold limit or the estimated threshold value is conducive for exportation. With regards to the threshold estimate of imports, it was only significant in the regime 2 which indicates that if there is the need for governments in sub-Sahara Africa to improve importation of goods and services, then they need to operate above the estimated threshold point of 6.123%.

4.5 Objective Four: the role of institutional quality on infrastructural development and international trade in sub-Saharan Africa

This is the fourth and final objective of the study. In this objective, the study intends to examine the role of institutional quality in relation to infrastructure development and international trade in sub-Saharan Africa. This is where the study uses institutional quality which serves as the mediating role between infrastructure development and international trade.

Below are the preliminary findings uncovered through this objective. The preliminary findings include the descriptive statistics and correlation co-efficient.

4.5.1 Preliminary findings

This section of the objective provides details into the initial discussions of the which is made up of the descriptive statistics and the correlation co-efficient of all the variables employed in the study to achieve this objective.

4.5.1.1. Descriptive Statistics

This is an aspect of the preliminary findings. The descriptive statistic of this objective describes the behaviour of all the variables employed to achieve this objective. The descriptive statistics contains the mean, standard deviation, maximum, minimum, skewness, kurtosis, co-efficient of variation, observation among others. Table 4.14 contains the descriptive statistics of the variable for the period of 2020.

Table 4. 14: Descriptive statistics

	GE	PS	CoC	RQ	IM	EX	TO	ICT	PD	GFCF
Mean	26.565	29.882	38.831	18.339	37.479	26.287	59.565	-1.547	23.793	20.798
Std. Dev	20.682	22.437	23.301	16.220	21.406	15.056	33.750	5.319	11.931	8.898
Max	76.442	89.151	90.865	74.519	111.385	77.191	175.099	6.989	47.016	42.911
Min	3.365	2.830	6.731	0.112	4.830	4.984	0.785	-14.868	3.850	0.110
CV	0.779	0.751	0.600	0.884	0.571	0.573	0.567	3.438	0.501	0.428
Skewness	0.950	0.923	0.576	1.540	1.815	1.125	1.202	-0.761	0.313	-0.026
Kurtosis	-0.251	0.132	-0.811	2.340	3.623	1.746	2.742	0.176	-0.712	0.272

Note: GE=Government Expenditure; PS=Political Stability; CoC=Control of Corruption; RQ=Regulatory Quality; IM=Imports; EX=Exports; TO=Trade Openness; ICT=Information Communication Technology Adoption; PD= Port Development; GFCF= Gross Fixed Capital Formation; Std Dev=Standard Deviation; Max=Maximum; Min=Minimum; CV=Co-efficient of Variation.

The table above (4.14) shows the descriptive statistics of the variables of the study for the year 2020. With regards to the variables of institutional quality, it was revealed that the average data for government effectiveness was 26.565. This means that, countries in sub-Saharan Africa scores 26.565% when it comes to how effective governments are. This further shows that, government effectiveness in sub-Saharan Africa is poor. With a score of 26.565% out of 100 shows that, there is more they need to be done. With a standard deviation of 20.682 shows how dispersed the data for government effectiveness are. The skewness value of 0.950 shows that its positively tailed or tailed to right. Also, political stability showed an average value of 29.882% indicating that the political atmosphere in sub-Saharan Africa is not serene and this is not surprising due to the past and recent coup d'état been recorded. Further, the maximum value of political stability was 89.151% which showed the period between 1990-2020 when military intervention in the various economies were at a minimal rate. The positive skewness shows that most of the value for political stability is positively tailed. The kurtosis for political stability is 0.132 which shows that the data for political stability is leptokurtic in nature. Also, control of corruption which is an indicator for institutional quality depicted an average score of 38.831%. This means that, corruption control in sub-Saharan Africa is weak and more needs to be done. This is not surprising that most of the countries in sub-Saharan Africa is known to be corrupt. Interestingly, the maximum score of control of corruption for the year under review (2020) is 90.865%. This indicates that, some of the countries in sub-Saharan Africa is instituting policies that is geared towards reducing corruption and its related activities. This is considered as a good sign. However, the minimum value of 6.731% also shows that, corruption is still a fight that needs to be fought hard and diligently in sub-Saharan Africa. This value also showed a skewness of 0.576 indicating that it is rightly skewed in nature but

leptokurtic. The standard deviation shows that, the value for the mean is not a true representation of the data for political stability as some of the values for the data are known as outliers. Moreover, the last variable for measuring institutional quality is regulatory quality. This is where the quality of the various regulatory institutions in the countries comes into play. From the table above, it was shown that, regulatory quality has an average value of 18.339% and this means that, countries in sub-Saharan Africa have weak institutions of which they are not able to regulate the activities of some of the organizations involved. The maximum value recorded for regulatory quality is 74.519% and the minimum is 0.112%. The minimum value recorded for regulatory quality shows that, some of the countries regulatory institutions does not function at all and with the maximum value recorded showing that, some of the countries in sub-Saharan Africa has a strong regulatory body that makes thigs function properly in the country. The skewness of 1.540 shows that the value for regulatory quality is right tailed with the kurtosis value of 2.340 shows that it is leptokurtic in nature.

Concerning the measures of international trade, the study proxied international trade with imports, exports, and trade openness. It was revealed through one of the proxies of international trade (import) that the average importation made in 2020 regarding countries in sub-Saharan Africa was 37.479 as a percentage of gross domestic product. This means that, most of the things that the citizens needs were imported into their respective countries. A standard deviation of 21.406 shows that there are outliers when it comes to the values of international trade through imports. This further means that, the mean value is not a true representation of the data for imports. In the year 2020, the maximum value for imports was 11.385% as a percentage of gross domestic product. This means that, some of the countries in sub-Saharan Africa imported more goods than the total production value of the same period. This is extremely bad, and it further

increases the balance of payment deficits. However, the minimum value for imports was 4.830% indicating that, some countries relied less on importation over the period. The skewness value of 1.815 and kurtosis of 3.623 shows that the data for imports are positively skewed and observed a normal distribution property respectively. On the other variable of international trade, which is export, it was seen that, the average value exports among countries in sub-Saharan Africa is 26.287% against the total value of gross domestic product for the period. This means that, though some of the countries tried as much as possible to export some of the goods produced in their respective countries, but it is not as much as the amount imported over the same period. This indicates that, more exportation needs to be done. Regarding the maximum and minimum value, it was realised that 77.191% was recorded as the maximum value for exportation over the period. This means that, though some exportations were done in this regard, but it is lesser than the maximum value of the imports. This further reveal that, some countries in sub-Saharan Africa are improving upon their productivity levels which warrants more exportation which in turn improve their balance of payments. Also, the minimum value recorded for exports for countries in sub-Saharan African for the year 2020 was 4.984%. This suggest that, in a few years to come, countries in sub-Saharan Africa will be able to export more if the right policies are put in place and that the potential for international trade is huge. Furthermore, a value of 0.573 which represent the co-efficient of variation shows that the data for export is least dispersed. The data for export is known to be leptokurtic in nature and positively skewed with a value of 1.746 and 1.125 for kurtosis and skewness respectively. On the last variable used to proxy international trade (trade openness) which is an aggregate of both imports and export variables. It was seen that the average 59.565% which means that trade volumes in the sub region of Africa improved drastically and that there is potential for

improved trade due to consistent collaborations from various countries. The standard deviation of 33.750 and kurtosis of 2.742 shows their non-normal distributive properties and least dispersed with a co-efficient variation value of 0.567. the maximum trade openness value of 175.099% of gross domestic product shows that there was a lot of trading activities within the sub-Saharan Africa. This could be due to the influx of Covid-19 pandemic of which countries were trading among themselves to be able to curtail the wide spread of the pandemic.

Moreover, the study proxied the independent variable with infrastructure development. Some of the variable which measured infrastructure development in the study was information communication technology adoption, port development, and gross fixed capital formation. On ICT adoption, it was revealed that, countries in sub-Saharan Africa are not investing in ICT which is known as a soft infrastructure which the maximum value being 6.989% of gross domestic product. This means that more needs to be done. However, on port development and gross fixed capital formation. It was revealed that, there is constant development of the ports in sub-Saharan Africa, and this could be due to the fact that most of the revenue of the countries are derived through the port, and it is understandable for there to be improved in order to generate more revenue to the various states. However, the maximum value for all the proxies for infrastructure development shows that this is an aspect of the economy that most governments in sub-Saharan Africa has neglected.

Table 4.15: Correlation Co-efficient

	GE	PS	CoC	RQ	IM	EX	TO	ICT	PD	GFCF
GE	**1.000**									
PS	0.707	**1.000**								
CoC	0.889	0.733	**1.000**							
RQ	0.930	0.704	0.819	**1.000**						
IM	0.219	0.405	0.356	0.164	**1.000**					
EX	0.201	0.375	0.234	0.158	0.685	**1.000**				
TO	0.252	0.433	0.313	0.197	0.688	0.816	**1.000**			
ICT	-0.092	0.031	-0.037	-0.093	-0.171	0.035	-0.035	**1.000**		
PD	0.196	0.042	0.116	0.268	-0.351	-0.391	-0.315	-0.017	**1.000**	
GFCF	-0.006	-0.071	0.020	-0.036	-0.010	0.023	0.082	0.216	0.075	**1.000**

Note: GE=Government Expenditure; PS=Political Stability; CoC=Control of Corruption; RQ=Regulatory Quality; IM=Imports; EX=Exports; TO=Trade Openness; ICT=Information Communication Technology Adoption; PD= Port Development; GFCF= Gross Fixed Capital Formation.

The table above (4.15) depicts the results from the correlation co-efficient of the variables employed in the study. Correlation co-efficient shows the association existing between and among all the variables the study used. From the table (4.15), it was seen that the association between government effectiveness and all the other mediating variables was positive and strong association. This suggests that government effectiveness improve political stability, control of corruption and regulatory framework. Further, it was seen that government effective associated positive with all the proxies of international trade, but these relationships were seen to be weak and the association between government effectiveness and infrastructure development was negative and weak. Moreover, on the other variable of institutional quality, which is political stability, it was seen that there was a positive and strong association between control of corruption and regulatory quality. Also, political stability associated positively but weak with the proxies of international trade (import, export, and trade openness) and negatively with only gross fixed capital formation when it comes to the proxies for infrastructure development and positive relationship between port development and information communication technology adoption. These relationships are seen to be weak. Further, control of corruption as a measure of institutional quality established positive and strong relation which regulatory quality. This means that, when the various regulations in the country is put to maximum use, it has the tendency of reducing corruption and corruption related activities. Control of corruption further established positive but weak relationship with all the variables for infrastructure development and international trade except for information and communication technology adoption which established a negative but weak relationship. On regulatory quality, it was seen that there exist a positive but weak association between the variable of international trade, namely import, exports and trade openness. This means that,

regulatory quality improves international in sub-Saharan Africa due to their positive association. However, when it comes to the association between regulatory quality and the variables for infrastructure development, it revealed a negative association between all except port development. This means that, regulatory quality has the tendency of improving the development at the various port as it serves that the revenue gateway of most countries but established negative and weak association with gross fixed capital formation and information communication technology adoption.

Concerning the variables of international trade, imports established a positive and strong association with export and trade openness with a value of 0.685 and 0.688 respectively. This shows that, import promotes international trade among countries in sub-Saharan Africa. But on the association between import and the variables of institutional quality, it shows negative but weak association with all the variables. This simply suggest that import is a disincentive to infrastructural development in sub-Saharan Africa. This could be the reason why infrastructure development is low in sub-Saharan Africa because the import volumes are higher than the exports volumes. For the variable, export, export established positive and strong association with trade openness in sub-Saharan Africa with a value of 0.816 but on the relationship between export and infrastructure development, it showed a positive but weak association with information and communication technology and gross fixed capital formation with values of 0.035 and 0.023 respectively. Interestingly, the results shows that export impede infrastructural development at the port. Furthermore, trade openness established a positive but weak association with gross fixed capital formation but negative and weak association with information communication technology adoption and port development. On the variables of infrastructure development, it was seen that information communication technology adoption established a positive relationship

with gross fixed capital formation with a value of 0.216 but a negative relationship with port development with a value of 0.017. however, port development established a positive and weak association with gross fixed capital formation. This means that, a value of 0.075 suggests that countries in sub-Saharan Africa can improve their overall infrastructure when they take a critical look at the revenue generated at the various ports.

4.5.2 Findings and Discussions

The assessment and testing of the proposed research model using PLS-SEM are discussed in this part. There are three parts to it. By assuring the implementation of the agreed-upon decision criteria, the study assesses the measurement model for indicator reliability, internal consistency for reliability, convergent validity, and discriminant validity in the following sub-section. The main topics of the last section were the structural model's examination for issues with multicollinearity, quality of fit, significance of the path coefficient, impact and predictive relevance amplitude . The final portion focuses on how institutional quality and infrastructure development in sub-Saharan Africa affect global commerce.

4.6 Evaluation of the Measurement Model

Before the study evaluated the results emanated from the PLS-SEM estimator, the study first examined the measurement models adopted. It can be deduced through Hair, Hult, Ringle, and Sarstedt (2016, p. 105) that model estimation is the revelation of empirical measures of the nexus between the various indicators as well as the constructs (measurement models) as well as between the constructs (structural model)". The importance of the measurement model's evaluation or assessment is to help the study make comparison regarding the theory it has adopted with the facts it has obtained for

the inquiry. Depending on if a construct is formative or reflective, different criteria for assessing the measurement model are appropriate (Hair, Risher, Sarstedt, and Ringle, 2019; Urbach and Ahlemann, 2010). Before assessing the structural model, it was required to look at the measurement model's validity and reliability since the study's constructs were all reflective in character. This research tested the indicator's reliability, internal consistency for reliability, convergent validity, and discriminatory validity by making sure that the established decision-making rules are followed (Hair et al., 2019; Urbach and Ahlemann, 2010).

4.6.1 Reliability of Indicators

According to Urbach and Ahlemann (2010. p.10), the degree whereby "a measure or set of measures is consistent concerning what it actually intends to measure" is the definition of indicator dependability. The loadings of reflective indicators are tracked to evaluate the indicator's dependability. Utilising indicators with loadings of 0.708 or higher is advised since they show that the construct or latent variable accounts for more than 50% of the indicator's variation, ensuring the item's appropriate dependability (Hair et al., 2019). However, not every indication had a substantial loading on the related latent variables. They were thus taken out of the model (Gefen and Straub, 2005). That is, one of the indicators was below the minimal needed level when the study was originally done. Particularly, the infrastructure development's gross fixed capital formation (GFCF) was eliminated since its indicator loading was -0.002. After gross fixed capital formation was removed from the study because it could not meet the minimum threshold for the variable to proceed to the next stage, the model was again run using the PLS method. All other indicators strongly loaded on their respective hidden factors. This ultimately suggests that the various variables' indicators satisfied the required threshold conditions. This shows that they were a trustworthy indicator of

the latent variables. The results that had been generated were then used to analyse and assess the measurement model, in addition to the structural model. The indication loadings are shown in Figure 4.1.

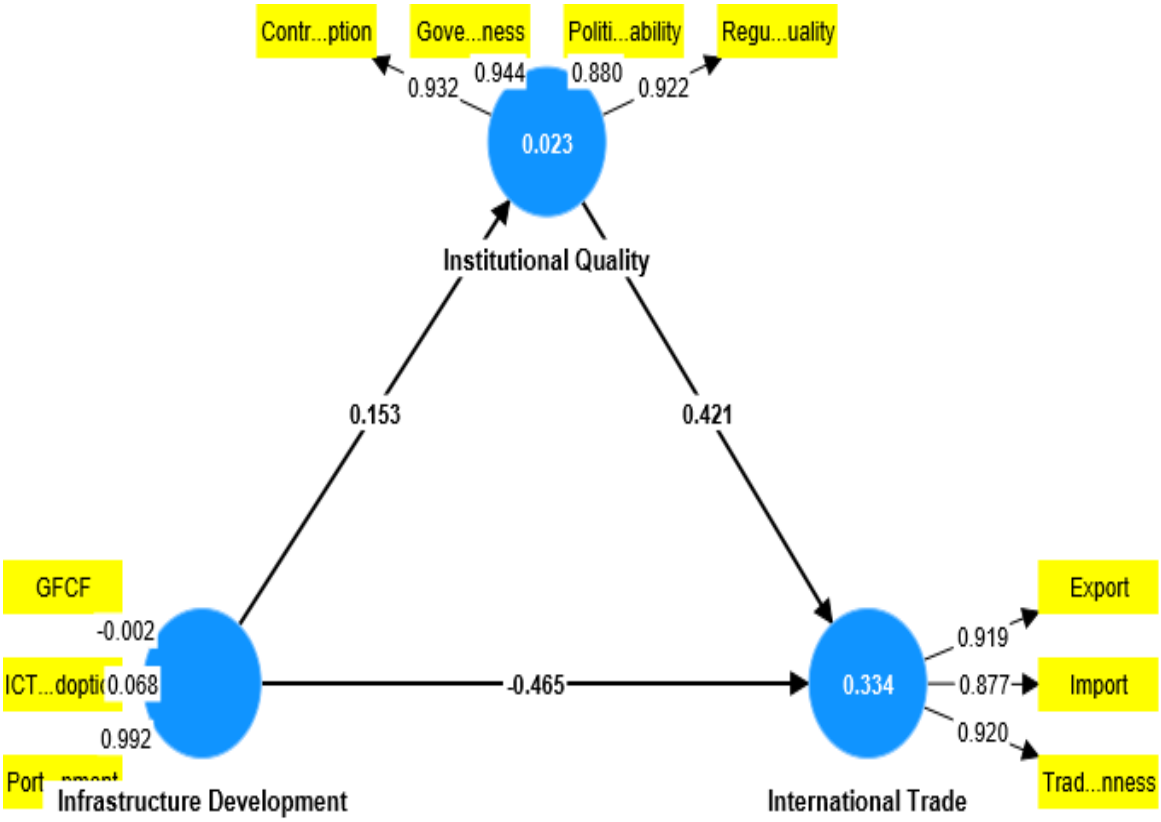

Figure 4.1: Results of PLS analysis

4.6.2: Reliability and Internal Consistency

Cronbach's alpha is used to assess the internal consistency quality once the indicator's correctness has been verified. The consistency and significance of all indicator scores for a latent variable are shown by the high alpha value of Cronbach's coefficient (Cronbach, 1951). In the works of Nunnally (1978), it was determined that the Cronbach's alpha cutoff value is 0.70. Moreover, table 4.16 shows that the Cronbach's alpha for each latent variable or construct is larger than 0.70. Some scholars and

researchers in the past decades have critiqued the Cronbach's alpha for showing lower values and being a less trustworthy measure of dependability since the items or variables are most often than not unweighted (Hair et al., 2019; Urbach and Ahlemann, 2010). Further, a replacement measurement for indicator dependability was therefore suggested and highly recommended. That is the composite reliability that Joreskog (1971) first indicated in his study. Joreskog (1971) developed composite reliability to address Cronbach's alpha's drawbacks (Urbach and Ahlemann, 2010). In contrast to Cronbach's alpha, which assumes that all indicators have the same loading, composite reliability indicates that all indications have distinct and different loadings (see Henseler, Ringle, and Sinkovics, 2009). The values indicates that, the greater values imply greater degrees of dependability; for instance, reliability scores between 0.60 and 0.70 are considered "appropriate and acceptable to exploratory research". Furthermore, Diamantopoulos, Sarstedt, Fuchs, Wilczynski, and Kaiser (2012) claim that values between the ranges of 0.70 and 0.90 indicate "satisfactory to good" and that values of 0.95 and above are viewed as problematic because they show that the items are greater than what is required, which lowers construct reliability. The composite reliability values of the findings, which range from 0.85 to 0.943 and indicate "satisfactory" to "good" dependability and that meet the required threshold for the estimation of the reliability and internal consistency through the composite reliability test.

Table 4. 16: Reliability and Internal Consistency

	Cronbach's Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Average Variance Extracted (AVE)
Infrastructure Development	0.701	0.851	0.872	0.503
Institutional Quality	0.940	0.942	0.943	0.846
International Trade	0.890	0.890	0.932	0.820

4.6.3 Convergent Validity

After evaluating and estimating the internal consistency reliability by looking at the Cronbach's Alpha and Composite Reliability, the study next proceeded to evaluate the convergent validity of each component of the main variables. The phrase "degree to which individual items reflecting a construct converge in comparison to items measuring different constructs" is used to characterise the idea of convergent validity in the study of Urbach and Ahlemann (2010, p.19). Furthermore, according to Fornell and Larcker (1981), the Average Variance Extracted (AVE) criteria is used to assess the convergent validity of the variables. For the study to get the average variance extraction, each indicator loading on a construct is squared. After the indicator loading of the construct is squared, the mean value is determined. One of the rules is the acceptance level of the average variance extracted and it indicates that a minimum acceptable value for average variance extracted is 0.50 (Hair et al., 2019). This is because the latent

component or concept accounts for at least 50% of the variability of the items, this suggests significant convergent validity (Hair et al., 2019; Urbach and Ahlemann, 2010). The average variance extracted values in Table 4.16 are more than the minimal value of 0.50, demonstrating that the convergence validity was high enough and suitable for the study to examine the mediating effects of infrastructure development and international trade nexus in sub-Saharan Africa.

4.6.4 Discriminant Validity

The study further continued with the preliminary tests and this time around, the study conducted the discriminant validity test. In the discriminant validity test it can be done using two criteria and they are the Fornell-Larcker and the cross-loading. The study satisfying one of the requirements for this test makes the data appropriate for the mediating effects to be examined. According to Hair et al. (2019, p.9), discriminant validity is known as the "degree to which a construct is empirically distinct from other constructs in the structural model." Two metrics are typically used in PLS-SEM to establish or evaluate discriminant validity. The Fornell-Larcker Criterion and cross-loading (1981). To evaluate the study's discriminant validity, the Fornell-Larcker Criterion was used. The outcomes are shown in table 4.17 below.

Table 4. 17: Discriminant Validity (Fornell-Larcker Criterion)

	Infrastructure Development	Institutional Quality	International Trade
Infrastructure Development	**0.706**		
Institutional Quality	0.149	**0.920**	
International Trade	-0.395	0.351	**0.906**

There are rules that the construct must agree to or some conditions that the constructs must me for the next estimation to be performed or done. The study therefore estimated the discriminant validity of the constructs using the Fornell-Larcker Criterion. According to a study by Fornell and Larcker (1981), a latent variable should share more variance with the indicators assigned to it than any other latent variable to achieve discriminating validity (see table 4.17 above). Simply put, each latent variable's AVE should be higher than its greatest square correlation with other latent variables. Table 4.17 shows that the various latent variables exhibit larger variation with their assigned indicators than with other latent variables. The numbers in the table are highlighted to show this. Also visible are the bold numbers, which show the highest values in both rows and columns. Therefore, the research may say that this situation satisfies the requirements of discriminant validity and that all the conditions have been met.

4.7 Evaluation of Structural Models

Testing the structural model comes after a successful validation of the measurement model (Hair et al., 2019; Urbach and Ahlemann, 2010). This is where the constructs have met all the conditionalities of the study and it is now appropriate for the study to evaluate the structural model where the effects as well as the mediating role is

examined. The structural model was evaluated using certain crucial methods recommended by Hair et al. (2019); Urbach and Ahlemann (2010). The following are the subsections that one needs to go through to evaluate the model.

4.7.1 Evaluating Multicollinearity Problems in the Structural Model

The examination of the structural model starts with a look at multicollinearity. In the works of O'Brien (2007), multicollinearity occurs in a multivariate regression analysis when many variables are mixed. This study assessed the multicollinearity by looking at the variance inflation factor (VIF) for each independent construct. There is a condition for the variance inflation factor condition to be met, where a minimum threshold of 5 must be utilised to avoid collinearity issues (Hair, Ringle, and Sarstedt, 2011). If this requirement is satisfied and conditions met, the construct under investigation is practically a perfect linear combination of independent variables, according to Hair et al. (2011), Hair et al. (2016), and Mansfield et al. (1982). Since none of the VIF values in Table 4.18 inner model matrix exceed 5, collinearity is not a concern in this investigation, and this allows the study to procced to the next phase.

Table 4. 18: Inner Model Matrix

	Infrastructure Development	**Institutional Quality**	**International Trade**
Infrastructure Development		1.000	1.023
Institutional Quality			1.023
International Trade			

4.7.2 Assessing the structural model for the significance of path co-efficient.

After examining collinearity, it is critical to evaluate the importance of the path coefficient between the model's latent variables (Urbach and Ahlemann, 2010). This is accomplished by doing a bootstrapping technique in SmartPLS using subsamples and a 0.1(10%) two-tailed distribution in the research. According to Streukens & Leroi Werelds (2016. p.2), bootstrapping is a "non-parametric resampling procedure" that "assesses the variability of a statistic by examining the variability of the sample data rather than using parametric assumptions to assess the precision of the estimates". Because PLS-SEM fails to show that the data is normally distributed, a non-parametric test must be applied (Hair et al., 2016). The bootstrapping approach produces t-statistics for the assessment of the direct and indirect influences (Hair et al., 2016). Table 4.19 presents the outcomes of these direct and indirect influences in infrastructure-international trade nexus in sub-Saharan Africa. Since a 95% confidence interval is considered, a minimum critical value of 1.65 is advised for a significance level of 10% (two-tailed) (Hair et al., 2011). The key t-values for all three hypotheses are 1.65 or higher, as shown in Table 4.19, indicating that all three are supported. This is where infrastructure development-institutional quality nexus showed a value of 3.674, 3.774

for infrastructure development-international trade nexus and institutional quality-international trade nexus depicted a t-stats of 2.862. The same outcome of the estimation is depicted below in a pictorial view named figure 2.

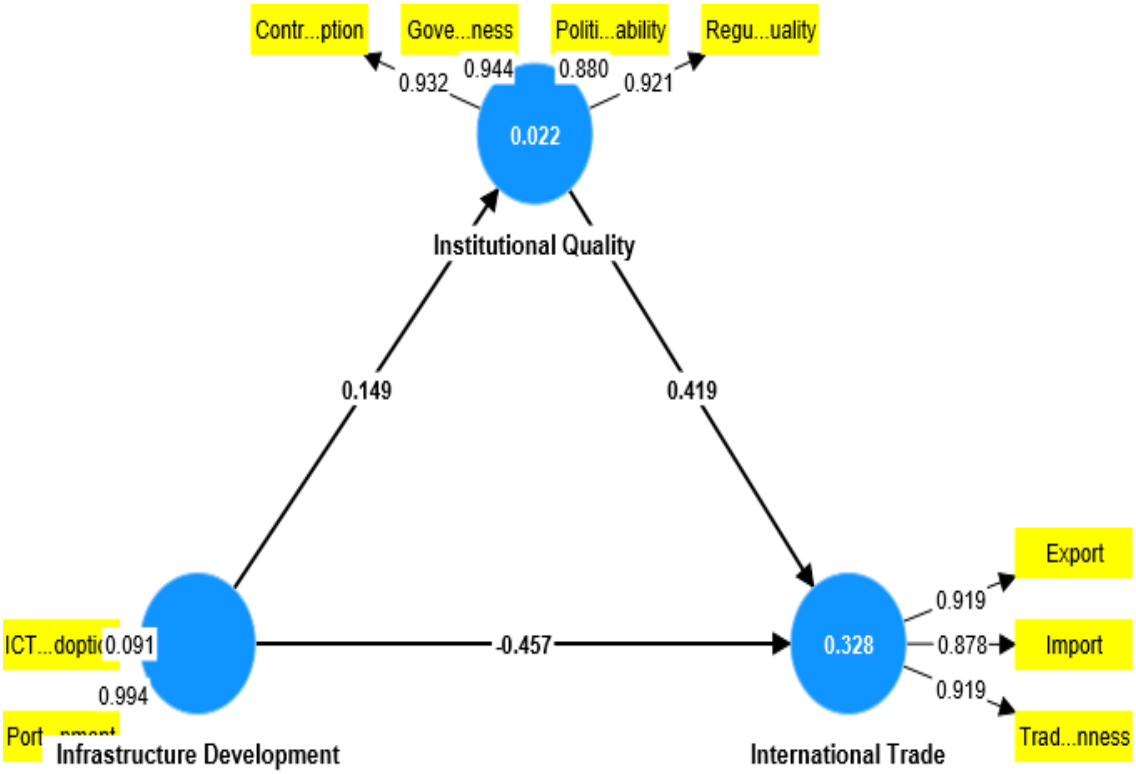

Figure 4.1: Hypothesis Testing for Direct Effect

Table 4. 19: Direct relationships for Hypothesis Testing

	Original sample (O)	**T statistics (|O/STDEV|)**	**P values**	**5.0%**	**95.0%**	**Inference**
Infrastructure Development ->Institutional Quality	0.149	3.674	0.002	-0263	0.454	Supported
Infrastructure Development –> International Trade	-0.457	3.774	0.000	-0.622	0.454	Supported
Institutional Quality –>International Trade	0.419	2.862	0.000	0.164	0.608	Supported

4.7.3 Assessing the Goodness of Fit

The significance of the path coefficient in the structural model was evaluated, and after that, the goodness of fit (GoF) of the model was ascertained. The model is either well- or poorly fitted, based on this assessment (Henseler et al., 2015). According to Dijkstra and Henseler (2015), the GoF test helps the researcher identify measurement and structural model misspecifications. The R square determination coefficient is the most used criteria (Hair et al., 2019). R square is a metric used to assess a model's capacity for explanation. It symbolises the total of the effects of the external latent variables on the endogenous latent variable, according to Hair, Sarstedt, Hopkins, and Kuppelwieser (2014). R square has a range of 0 to 1 and rises with increasing explanatory power. R-square values of 0.25, 0.50, and 0.75 are classed as weak, moderate, and significant, respectively, by Hair et al. (2011) and Henseler et al. (2009). R square values around 0.333 are considered typical, values around 0.190 are weak, and values around 0.670 are relatively significant in social science research (Chin, 1998). The model's R square is 0.749, which is noteworthy in social science research, as shown in Table 4.20. According to this, the exogenous latent variable sum explains 67% of the variations in the endogenous components. Urbach and Ahlemann (2010) and Hair et al. (2019) are two references.

Table 4. 20: Indirect relationships for Hypothesis Testing

	Original sample (O)	**T statistics (|O/STDEV|)**	**P values**	**5.0%**	**95.0%**	**Inference**
Infrastructure Development ->Institutionnel Qualité->International Trade	0.062	0.641	0.002	-0.086	0.225	Supported

Mediating effects of institutional quality on infrastructure development and international trade.

The objective of the study is to examine the mediating role of institutional quality in infrastructure-trade nexus in sub-Saharan Africa. This mediating effect of institutional quality on infrastructure-trade nexus in sub-Saharan Africa has not been explored as a viable means of improving trade in this part of the globe despite the numerous trade agreements. In filling this gap, the study explored the role that institutional quality plays in improving international trade through developed infrastructure. Adopting a cross-sectional data involving 43 countries in sub-Saharan Africa for the year 2020. The study formulated three hypotheses for the direct effects or relationship and one hypothesis for the indirect relationship of which institutional quality serves as the mediating role in infrastructure development-international trade nexus. The direct effects hypothesis includes, infrastructure-international trade nexus, infrastructure-institutional quality nexus and institutional quality on international trade nexus. It was discovered through the study that; all four hypotheses for both direct and indirect effects were supported. That is, the study failed to reject all the null hypothesis. This means that, institutional quality is the missing link in infrastructure-trade nexus in sub-Saharan Africa. Institutional quality variables such as control of corruption, political stability, government effectiveness and regulatory quality are the key variables which when implemented can improve international trade in sub-Saharan Africa. Interestingly, control of corruption is when the various governments in sub-Saharan Africa put measures or policies aimed at reducing corruption and its related activities to a minimum. It is a known secret that corruption impedes international trade and is known to be prevalent in sub-Saharan Africa and Africa. Corruption and its related activities in Africa in general make investors shy away from investing in the economy because

of fear that their investments will be drained through corruption and also, they harbour the belief that they need to "part away" with huge sums of money before they can get favourable working environments from the governments or influential individuals through the various state agencies and this affects their willingness as well as their readiness to invest in sub-Saharan Africa for international trade volumes to be improved. Furthermore, they believe that the money they will lose through corruption can be used to further invest in their business to improve productivity and enjoy economies of scale, which in turn lowers production costs and increases profits. It is, therefore, not surprising that the volume of international trade is not as expected in sub-Saharan Africa despite the numerous trade agreements in place with the recent one being signed in 2020. This confirms the supported hypothesis that when corruption is controlled in sub-Saharan Africa, trade volumes will improve as more investors will be encouraged to trade in this part of the globe.

Moreover, one of the prevailing problems in sub-Saharan Africa is political instability in both past and recent times. For the past 5 years, there has been numerous political unrests in more than ten (10) countries in sub-Saharan Africa and not less than 6 democratic governments have been overthrown through military takeovers. These happenings cast doubt on potential investors who intend to invest in sub-Saharan African countries subject to wars and political unrest. This where, political stability serves as the conduit for international trade as one of the factors that investors consider when engaging in international trade, that is, the peace that the country is enjoying. Moreover, political stability can therefore serve as the link between infrastructure development and international trade and thus if the political atmosphere in countries in sub-Saharan Africa is stable, then trade volumes will surge. A vivid example is when one of the automobile companies were to choose between citing their assembling plant

in either Ghana or Nigeria, the company chose the former because of the stability of their political atmosphere and rejected the latter due to political instability or unrest in some parts of the country especially in the northern sector. Thus, political stability played a crucial role in the company choosing to cite its assembling plant in Ghana. This shows how crucial institutional quality is towards international trade in sub-Saharan Africa as it opens up the countries, the sub-region and the continent as a whole to international trade opportunities.

Furthermore, institutional quality if considered serious, can improve trade in sub-Saharan Africa. This is where institutional quality variable such as regulatory quality serve as the basis for quality of goods to be produced, hence meeting internationally acceptable standards. When international acceptable standards are met for goods produced in sub-Saharan Africa, the market for the goods and services increases thereby affording investors the opportunity for larger markets. Since investors aim to make a profit, a larger market acquired through quality goods will serve as a crucial motivation to improve trade international trade in sub-Saharan Africa, thereby improving international trade volumes. Another example is when some of the countries in sub-Saharan Africa was banned from trading their cash crops in the United Kingdom's markets due to their inability to meet international standard. This closes the door for larger markets of which it will serve as a motivation for investors to invest more in sub-Saharan Africa. This shows how crucial institutional quality, specifically regulatory quality is towards international trade in sub-Saharan Africa.

Moreover, one institutional quality variable, government effectiveness, also spurs international trade. The perception of the calibre of public services, the calibre of the civil service and the extent of its independence from political influences, the calibre of

policy formulation and implementation, and the credibility of the government's commitment to such policies are all included in the category of government effectiveness. Governments been effective has a significant effect on international trade in sub-Saharan Africa through infrastructure development. This is because, most of the investors see an effective government as the one that can provide them with the needed serene business environments that they need to be able to produce more in the country under discussion. This is where there will not be policies that is geared towards hampering productivity volumes in sub-Saharan Africa. Government effectiveness plays a crucial role towards improving international trade in sub-Saharan Africa.

However, on the direct effects, it was revealed that, infrastructure development improves international trade, institutional quality improving international trade and institutional quality improving infrastructure development. This finding of institutional quality playing a crucial role in infrastructure-trade nexus is in conformation with numerous studies which affirm the importance of institional quality in international trade. Some of these studies includes Ochieng et al (2020) uncovered that institutions spurs international trade. Also, Beugelsdijk et al. (2018) indicated in their study that, institutional quality has been more significant in international trade. Furthermore, Gani and Scrimgeour (2016) examining the interactions between institutions through rule of law, and the effectiveness of the legal system in encouraging investments and enchansing economic performance through international trade and uncovered that, institutional quality establish smooth access to improve trade especially in developing economies. Gani and Scrimgeour (2016) assert that the preservation of the rule of law, the efficient enforcement of business and trade agreements, the avoidance of bureaucratic hurdles, the enhancement of the regulatory framework, and the facilitation of unrestricted exercise of political and civil liberties are crucial factors in promoting

trade. These studies demonstrate that the quality of institutions is of utmost importance and has a substantial influence in facilitating international trade. This shows that, the missing link in countries located in sub-Saharan Africa with regards to international trade is infrastructure development supported by institutional quality.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This is the final chapter of the study. This section of the study details the essential findings uncovered through the study in addition to the policy recommendations curved out of the findings to help countries in sub-Saharan Africa improve infrastructure development with the aim of improving international trade for the benefit of the numerous trade agreements signed among themselves to manifest. Conclusion is drawn from the findings the study revealed as well as the contribution of this study to literature is documented to establish the essential nature of the study.

5.2 Summary of findings

The general objective of the study is to examine the infrastructure development and international trade nexus in sub-Saharan Africa emanating from the backdrop of numerous trade agreement existing in this part of the globe. The study outlined four specific research objectives to achieve using different methodological approaches for each objective. In relation to the study, the following are the four specific findings that were uncovered or revealed.

5.2.1 Objective One: Effects of Infrastructure Development on International Trade in sub-Saharan Africa.

This is the first objective of the study. In this objective, the study intends to examine the effects of infrastructure development on international trade using the generalized methods of moment approach. The results showed that GFCF positively and significantly (at a 1% level) increases international trade (import and export). This demonstrates that the GFCF is essential to economic operations in Sub-Saharan Africa,

and as a result, more must be done to enhance the region's infrastructure basis to obtain maximum benefits from the numerous trade agreements signed, such as the recent Africa Continental Free trade Area. However, the findings for building showed a "mixed" picture, as it both encourages international trade (export) and inhibits it (import) in Sub-Saharan Africa. This indicates that whether a government wants to increase exports or not, the impact of port development depends on that country's goals. Additionally, both proxies of foreign trade are significantly impacted by government spending. This suggests that because government spending has a beneficial influence on trade, it is essential to increase government spending to improve global trade. Interestingly, the conclusions for population and inflation were different. The high population density and low-income levels of Sub-Saharan African nations may be a contributing factor to their incapacity to enhance international trade.

5.2.2 Objective Two: The transmission channels with which infrastructural development affects international trade in sub-Saharan Africa in the short and long run.

This is the second objective of the study. After examining the impact of infrastructure development on international trade using the generalized methods of moment, the study further examined the sectorial effects of infrastructure development and international trade using the pooled mean group methodology by paying critical attention to its short and long run implications. The study's empirical findings demonstrated the critical role that infrastructure development plays in global trade over the long and short terms. It was realized that apart from ICT Adoption, all variables of infrastructural development impacted negatively for export but positive for import in the short run. However, in the long run, it was revealed that all the infrastructural development variables positively impacted exports. This implies that infrastructural development is key towards

international trade especially in countries (sub-Saharan Africa) efforts to improve trade for balance of payment deficit experienced to reduce. Also, the service sector realized a positive impact in the short run through ICT Adoption regarding exports and a negative but highly significant impact through gross fixed capital formation and port development for imports. However, the negative impact in the short run changed to a positive and significant impact for imports at all conversional levels in the long run. This finding implies that the growth of the service sector in sub-Saharan Africa is a conduit for international trade as the long-term positive impact shows that the service sector will bridge the balance of payment gap with the right policies. Moreover, in the manufacturing sector, it was revealed through the study that ICT Adoption, gross fixed capital formation and port development impact the positively through export in the short run, same outcome was established in the long run but in this situation all the variables for infrastructural development are highly significant at 1%. This sector positively impacts import when proxied with gross fixed capital formation and port development in the long run but negative in the short run when proxied with ICT Adoption. Finally, it was seen that agriculture showed positive and significant effects on international trade with ICT Adoption and gross fixed capital formation. Port development showed an adverse and significant effects in the long run. In the nutshell, the growth of a particular sector in sub-Saharan Africa is crucial towards international trade especially in exportation. Based on this, governments in sub-Saharan Africa should prioritize developing the various economic sectors, especially the service and agricultural sectors, known as the engine of growth.

5.2.3 Objective Three: The threshold effects of infrastructural development on international trade in sub-Saharan Africa.

This third objective of the study aims to examine if the effects of infrastructure development on international trade in sub-Saharan Africa are specific. This is where the Hassen (2000) threshold sampling splitting approach was employed to determine the shape of the threshold and if more development of infrastructure is good or bad for international trade. This study empirically revealed that, the threshold effect of gross fixed capital formation on all the proxies of international trade is U-shaped. That, it is economically good to operate below the threshold estimate for the impact to be gained especially when it comes to exports. Further, ICT Adoption and port development established a U-shaped and an invented U-shape with export and import respectively. This means that, depending on the aims and aspirations of the country, ICT adoption and port development is key to international trade in sub-Saharan Africa.

5.2.4 Objective Four: The role of institutional quality on infrastructural development and international trade in sub-Saharan Africa.

This is the last objective of the study. In this objective, the study intends to know the mediating role of institutional quality in infrastructure development and international trade nexus. Here, the study adopted the PLS SEM in estimating the mediating role. It was revealed that, institutional quality through political stability, control of corruption, government effectiveness and regulatory quality play a significant role in the infrastructure and international trade nexus in sub-Saharan Africa and thus, there is a need for them to be encouraged and used for trade volumes to increase on this part of the globe. This was based on the fact that; institutional quality supported all the hypotheses established with regards to the direct and indirect effects. This further shows that, infrastructure development is key to international trade in sub-Saharan Africa but

without the strictly adherence to the measures of institutional quality, the intended benefits of the various trade agreements cannot be met or achieved.

5.3 Conclusion

This study embarked to re-examine the infrastructure development and international trade nexus but focused on countries located in sub-Saharan Africa. Interestingly and essential findings were revealed through the study, which adds to the unique benefits derived from the infrastructure-international trade nexus. It can therefore be concluded that, infrastructure development is key towards gaining maximum benefits from international trade because of the trade agreements existing among countries especially countries located in sub-Saharan Africa. This is because international trade is an integral part of countries and one of the major contributors to international trade. This study re-affirms the crucial role that infrastructure development plays in improving international trade. Without improving the infrastructure base, countries in sub-Saharan Africa will continue to record low sales volumes when it comes to international trade.

5.4 Policy recommendation

After the various findings have been uncovered in the study from the first objective to the fourth and final objective, that infrastructure development is essential towards international trade in sub-Saharan Africa and as such, governments from the various countries in sub-Saharan Africa must initiate policies that are geared towards earning maximum benefits from the numerous trade agreements in place. Below are some of the policy recommendations the study outlined for implementation.

First and foremost, the study's findings revealed that infrastructure development spurs international trade in sub-Saharan Africa, and their attention will be drawn towards road infrastructure. Based on the findings above, the study recommends that governments in

the region need to make significant investments in their underdeveloped infrastructure for it to be improved, which is currently seen in different countries especially in developed economies or countries. The low levels of international trading observed in member countries can be attributed to the current gap in infrastructure development in the form of roads, technology, and communication, among other things. Due to their advanced infrastructure, western Europe and the United States may account for higher trade volumes. The Africa Continental Free Trade Area will merely be one of the many agreements on paper without accomplishing its stated aims or objectives without improvement in the infrastructure systems of member nations. Also, various governments in sub-Saharan Africa should place a high priority on capital spending since it has better and more potential to have a positive impact on trade in sub-Saharan Africa.

Secondly, the study uncovered that the various sectors play a crucial role in improving international trade in sub-Saharan Africa in both short and long run situations. Based on this finding, it is recommended that governments in sub-Saharan Africa develop policies that prioritize developing the various sectors in their economy, especially the service sector and especially the agricultural sector known as the engine of growth. This is because the agriculture sector employs more than half of the active population in sub-Saharan Africa. Concentrating on that aspect is a potential for improving trade as policies geared towards the agriculture such as free fertilizer and other agriculture inputs, will help improve international trade in sub-Saharan Africa.

Furthermore, in examining the threshold effects of infrastructure development and international trade nexus, the study empirically revealed that, the threshold effect of gross fixed capital formation on all the proxies of international trade is U-shaped. That, it is economically good to operate below the threshold estimate for the positive impact

to be gained especially when it comes to exports. Further, ICT Adoption and port development established a U-shaped and an invented U-shape with export and import respectively. This means that, depending on the aims and aspirations of the country, ICT adoption and port development is key to international trade in sub-Saharan Africa and as such countries must keenly watch them. Based on the findings uncovered above, the study recommends that governments in sub-Saharan Africa should invest heavily in infrastructure development especially in ICT development, roads, warehouses among others and should be mindful of not spending above the threshold else it becomes a disincentive for international trade, specifically exports. Also, governments in sub-Saharan Africa should make sure to prioritize operating above the threshold estimate when it comes to gross fixed capital formation (overall infrastructure development of a country). Moreover, in deriving the needed positive impact from ICT Adoption, there is the need for governments in sub-Saharan Africa must operate below the estimated threshold when it comes to export and below the threshold when it comes to imports.

Last but not the least, the study revealed the immersed role of institutional quality in relation to infrastructure development and international trade in sub-Saharan Africa. It was seen that; institution quality is crucial towards trade in this part of the globe. Based on this finding, the study recommends that, regulatory quality, control of corruption, political stability and government effectiveness should be of paramount interest to governments in all the countries understudied. This is where policies are geared towards improving the quality of institutions. Policies such as imprisonment for corruption and its related activities as an example will make it a disincentive for others to engage in, thereby improving the chances of increasing volumes of trade as investors will have confidence in the system being operated and that they will get value for money on the investments that intend to be embarked on in the country.

5.5 Contributions to Literature

This study has made some contributions to the literature on infrastructure development and international trade nexus. This study is novel and contributes to literature through three (3) main themes which are contribution to empricis, methodology and practice.

On its methodological contribution to literature, the study contributes to literature with regard to the methodology employed in the study. The adoption of pooled mean group, the sampling splitting approach, the partial least squares approach are all new and noval methodologies incorporated into the infrastructure development and international trade nexus. This is because, previous studies just estimated the casual effects between infrastructure and international trade without estimating its short run and long run effects as well as the exact threshold estimate which makes infrastructure development spur or inhibit international trade in sub-Saharan Africa. This makes the study unique and worth the time dedicated to.

Furthermore, the study makes crucial contributes to the world of empirical literature through its threshold estimation which gives evidence to the exact point through which infrastructure development spurs international trade or otherwise. The threshold estimation provides evidence of each variable and how each variable can be maximize to promote trade. Also, the transmission chanel through which infrastructure development promotes trade is empirically evident in this study as previous studies failed to incorporate how the various sectors contributes to international trade. This study estimated how service sector, manufacturing sector, and agricultural sector spurs international trade in the short and long run dimensions. This was not captured in previous literatures.

Moreover, this study further contributes to practice. In practice, the findings of this study will help governents to understand the crucial role of infrastructure development

towards international trade in sub-Saharan Africa based on the backdrop of numerous trade agreements signed in this part of the globe. It will also inform countries or economies on the sector to look at when they want either short run or long run importance. Also, the role of institutional quality through control of corruption, government effectiveness, political stability, and regulatory quality are clearly uncovered for managers of economies to make informed decisions based on them to promote international trade.

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APPENDIX 1

Sampled countries in sub-Sahara Africa

Angola	Congo Republic	Lesotho	Senegal
Benin	Cote d'Ivore	Liberia	Seychelles
Botswana	Equatorial Guinea	Madagasca	Siera Leone
Burkina Faso	Eritrea	Mali	South Africa
Burundi	Ethiopia	Mauritania	Sudan
Cape Verde	Gabon	Mauritius	Tanzania
Cameroon	Gambia	Mozambique	Togo
Central African Republic	Ghana	Namibia	Uganda
Chad	Guinea	Niger	Zambia
Comoros	Guinea Bissaw	Nigeria	Zimbabwe
DR Congo	Kenya	Rwanda	