INFRASTRUCTURE DEVELOPMENT, TRADE, AND ECONOMIC GROWTH IN THE EAST AFRICAN COMMUNITY: AN EMPIRICAL ANALYSIS

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DECLARATION

DECLARATION

This thesis is my original work and has not been presented for an award of a degree, diploma or certificate in this or any other university.

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DEDICATION

To the memory of my mother, Dorcas Atieno Babu, who always gave me encouragement and believed in my academic ability.

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ABSTRACT

Infrastructure holds a central position in a country's economic activity, hence the need to do a comprehensive analysis of its specific contributions to an economy. In the last decades, the East African Community (EAC) governments have devoted significant public resources towards building new infrastructure projects in the region. However, growth has not been commensurate with increased public investment in infrastructure; in addition, the volume of trade has stagnated. Therefore, this study employed panel time-series technique and infrastructure augmented production function, to establish the short- and long-run relationship between infrastructure stock and economic growth using data for the period 1990-2019. The study also explored the possible channels through which infrastructure could manifest itself on growth by doing an in-depth analysis on key determinants of growth, like private investment and trade. Infrastructure stock index was constructed from public economic infrastructure including transport, energy, and communications. Data was obtained from various sources including the Socio-Economic database of African Development Bank, World Bank database, International Monetary Fund database and National Bureaus of Statistics of EAC Partner States. Panel data models for growth and private investment were analysed using pooled mean group estimation technique. The study established a cointegrating relationship between infrastructure stock and economic growth in EAC and a uni-directional causality from infrastructure to economic growth. Using an error correction framework to capture the short-and long-run dynamics, the results confirmed that, public infrastructure investment crowds-out private investment in the short-run but crowds-in private investment in the long-run. The study estimated a gravity model augmented for both hard and soft infrastructures from transport and information and communications technology indicators using random effects model and Poisson Pseudo Maximum Likelihood method. Both methods confirmed that infrastructure stock is important in increasing the volume of EAC's trade. The policy implications are that increased investment is vital in economic infrastructure to increase infrastructure stock, encourage private sector activities and growth in the long-run. Macroeconomic stability is also crucial for private sector investment. Transport infrastructure has a greater impact on exports than Information and Communications Technology infrastructure and thus, it is important to channel additional resources towards increasing transport infrastructure stock. The study also found that, many documents required for exports lowers the volume of trade, hence it is critical to enhance border efficiency for more trade.

Key Words: Infrastructure Development; Economic Growth; Private Investment; International Trade; EAC

JEL Classification: H54; O47; R42; F10; F15

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

AfDB	African Development Bank
ADF	Augmented Dickey Fuller
APEC	Asia Pacific Economic Cooperation
ARDL	Auto-regressive Distributed Lag
ASEAN	Association of Southeast Asian Nations
CD	Cross-Sectional Dependence
CRS	Constant Returns to Scale
DRC	Democratic Republic of Congo
EAC	East Africa Community
ECCAS	Economic Community of Central African States
ECM	Error Correction Mechanism
ECOWAS	Economic Community of West African States
EU	European Union
FDI	Foreign Direct Investment
GATT	General Agreements on Tariffs and Trade
GDP	Gross Domestic Product
GFCF	Gross Fixed Capital Formation
GMM	Generalised Method of Moments
ICT	Information Communications and Technology
IMF	International Monetary Fund
IV	Instrumental Variable
LDCs	Less Developed Countries
LLC	Levin Lin Chu
LM	Lagrange Multiplier
LPI	Logistics Performance Index
MENA	Middle East and North Africa

MG	Mean Group
MTR	Multilateral Trade Resistance
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
PCA	Principal Component Analysis
PIM	Perpetual Inventory Method
PMG	Pooled Mean Group
PPML	Poisson Pseudo Maximum Likelihood
PVI	Private Investment
REC	Regional Economic Community
RGDPP	Real GDP per capita
SADC	Southern African Development Community
SSA	Sub-Saharan African
UNCTAD	United Nations Conference on Trade and Development
VAR	Vector Auto Regressive
WB	World Bank
WDI	World Development Indicators
WGI	World Governance Indicators
WITS	World Integrated Trade Solutions
WTO	World Trade Organization

DEFINITIONS OF TERMS

Contiguity: The sharing of a common land border by countries. For example, Kenya and Tanzania share a border at Namanga and that makes the two countries contiguous.

Economic Growth: Refers to real GDP's growth rate at constant United States Dollar.
Infrastructure Development: This implies increase in stock of economic infrastructure.

Infrastructure Quality: It is the degree to which infrastructure in a particular country meets certain defined international standards. It is based on indicators such as connectivity, access, reliability, efficiency, among others.

Hard Infrastructure: Refers to physical infrastructure which includes roads, airports, ports, and rail.

Perpetual Inventory Method: A method used to derive capital stock series using data on investments.

Pooled Mean Group Method: A panel time series estimation technique which involves both pooling and averaging of series data.

Principal Component Analysis: A method used to transform a large data set to a simplified structure; it is used in this study to aggregate various forms of infrastructure.

Private Investment: It is the acquisition of capital assets by the private sector.

Soft Infrastructure: Refers to time, cost, and the number of documents needed during trade across borders. It can also refer to rules and regulations governing a nation, programs, financial systems and structures in organizations.

Trade Costs: Refers to costs of transaction and transportation related to the exchange of goods and services across country borders.

Trade Facilitation: Refers all the measures meant to simplify, modernize and harmonize export and import processes between partners.

CHAPTER ONE

INTRODUCTION

1.1 Background

Infrastructure is core to growth process in different regions across the globe. The outcome of economic growth due to advancement of infrastructure has welfare enhancing effects in a country and lowers inequality levels (Bhattacharya et al., 2015). Increased infrastructure development can promote economic growth by at least 2 percent per year; this is true for different developing economies in Africa, Latin America and Asia (Calderon and Serven, 2010). Therefore, sustainable infrastructure investment will ensure success of global efforts to attain the Sustainable Development Goals (SDGs) such as building of reliable and durable regional infrastructure to promote access to basic resources by the rural population and to enhance economic progress.

Different types of infrastructure enhance international trade. Hard infrastructure is critical for inter-country trade globally. They include airports, ports, railway lines, and roads. Soft infrastructure influences trade: it is linked to time, cost and documentation required for cross-border trade (United Nations Conference on Trade and Development, 2013). Infrastructure quality[1] of a country determines volume of international trade by influencing trade costs. Further, since different sectors use infrastructure facilities uniquely, infrastructure quality influences the specialization and opportunity cost in international trade (World Trade Organization, 2004).

Access to quality and reliable infrastructure for instance roads, transport, electricity and information and communications technology (ICT) is vital for boosting industrial activities that in the end, leads to better standards of living through employment creation and economic growth (United Nations Industrial Development Organization, 2016). Infrastructure development speeds-up the process of economic development by encouraging more production and results in lower cost of participating in domestic and international trade. Increased infrastructure services results in industrialization and more employment opportunities are generated, resulting in low-poverty levels in a country (Sahoo et al., 2010).

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[1] This is given by an index that describes a country’s level of infrastructure development. Where, 1 indicates to very low infrastructure while 7 implies infrastructure that is efficient and extensive by international standards (World Economic Forum, 2019).

Infrastructure is very important towards attainment of SDGs through accelerated growth and improved welfare of the population. For example, Medeiros et al. (2020) found that infrastructure development has a positive impact on poverty reduction among households in Brazil. Similar results were obtained for Mexico in a study by Mora-Rivera and Garcia-Mora (2021). However, in comparison to other regions globally, the level of infrastructure development in Africa still ranks behind even though infrastructure drives many activities in any economy. Africa still faces the challenges ranging from poor accessibility to quality infrastructure and high cost of service provision (Jerome, 2011).

1.1.1 Infrastructure Quality and Regional Share of World Exports

Infrastructure remains one of Africa's development challenges. Inadequate infrastructure limits Africa's competitiveness and economic activity. According to World Bank (2017), in comparison to other developing regions of the world, Sub-Saharan Africa (SSA) ranks last in almost all dimensions of infrastructure. In 2018, SSA had a score of 2.2 according to the World Bank's logistics performance index based on quality of infrastructure related to trade and transport. In 2018 and 2019, SSA had the lowest score of 46.3 and 45.0 (0=low and 100=high) respectively based on the Global Competitiveness Report of the World Economic Forum (WEF).

Table 1.1 indicate the performance in trade and transport linked infrastructure by different regions of the world between 2007 and 2018. Where 1=low infrastructure quality and 5 = high infrastructure quality.

Table 1.1: Quality of Trade and Transport Related Infrastructure

	2007	2010	2012	2014	2016	2018	Average
North America	4.01	4.09	4.07	4.12	4.15	3.9	4.06
Euro Area	3.42	3.44	3.47	3.56	3.64	3.51	3.51
East Asia & Pacific	2.88	2.94	3.03	3.16	3.02	3.05	3.01
MENA	2.56	2.74	2.68	2.72	2.78	2.76	2.71
South Asia	2.07	2.12	2.38	2.34	2.45	2.33	2.28
SSA	2.11	2.05	2.30	2.27	2.29	2.20	2.20
World	2.58	2.63	2.77	2.77	2.75	2.72	2.70

Data Source: World Bank (2020) World Development Indicators (WDI)

The statistics in Table 1.1 show that SSA region has poorest trade related infrastructure compared to other regions. In addition, the region's performance was below the world average between 2007 and 2018. Inadequate infrastructure in SSA leads to higher transport costs, hence limiting both intra-and inter-regional trade.

The proportion of merchandise exports in world exports for SSA and other regions between 2000 and 2019 is shown in Table 1.2.

Table 1.2: Merchandise Exports as Share of World Exports (percent), 2000-2019

	2000	**2005**	**2010**	**2013**	**2016**	**2019**	**Average**
North America	16.30	11.92	10.81	10.68	11.40	11.01	12.02
Euro Area	29.65	30.22	26.25	24.49	25.79	25.40	26.97
East Asia & Pacific	27.26	27.67	31.15	30.97	33.62	33.51	30.69
MENA	4.97	6.18	6.99	8.06	5.73	5.80	6.29
South Asia	0.99	1.26	1.80	2.00	2.06	2.11	1.70
SSA	1.49	1.93	2.36	2.21	1.64	1.77	1.90

Data Source: World Bank (2020) WDI

SSA's merchandise exports as a share of world exports stood at 1.49 percent before increasing to a high of 2.36 in 2010. The increase in share of SSA's exports was in part due to boom in primary commodity prices and increase in export of fuels, ores and metals, whose share in total SSA's exports increased from 50 percent in 2000 to 66 percent in 2010 (Schmieg, 2016). The SSA's share however dropped to 2.21 percent in 2013 and further to 1.64 percent in 2016 due to a decline in commodity prices (International Monetary Fund, 2016). Between 2000 and 2019, the share of SSA's merchandise exports in world exports averaged 1.90 percent, slightly above than the South Asia's average of 1.70 percent. In comparison to other regions globally, SSA and South Asia have the lowest share of merchandise exports. East Asia and Pacific and Euro Area have the largest share of merchandise exports, averaging 30.69 and 26.97 percent respectively. This indicates that the countries in SSA are not performing well in international trade in terms of goods exports. High trade logistics cost is one of the factors that hinder the competitiveness and export diversification[2] by African countries (World Bank, 2017).

Less developed countries (LDCs) incur higher trade costs compared to other countries. The manufacturing sectors in LDCs incur trade costs as high as 227 percent (of their ad-valorem tax equivalent). For the lower-middle income and upper-middle economies, the costs were

[2] This refers to both product and market diversification

125 and 98 percent respectively, while for the high-income economies, the costs were around 82 percent (World Trade Organization, 2015). Therefore, compared to the developed countries, infrastructure in LDCs explains a higher proportion of trade costs. Low share of SSA's exports in world trade is partially linked to higher trade costs due to inadequate infrastructure. Table 1.3 presents the cost to export by different regions around the world.

Table 1.3: Average Cost to Export by Region, US$, 2014-2019

	2014	2015	2016	2017	2018	2019	Average
North America	171.00	171.00	171.00	171.00	171.00	171.00	171.00
Euro Area	105.05	105.05	105.05	105.05	105.05	105.05	105.05
East Asia & Pacific	391.09	391.09	391.09	390.44	383.06	383.06	388.31
MENA	425.90	425.90	425.90	427.80	427.80	427.80	426.85
South Asia	377.21	377.21	369.96	363.58	347.23	347.23	363.74
SSA	601.34	602.59	605.89	605.89	605.89	605.89	604.58
World	398.63	399.23	401.02	400.32	396.43	396.43	398.68

Source: World Bank (2019) WDI

On average, regions such as Euro Area and North America have the least trade costs, partially attributed to well-developed infrastructure systems (Table 1.3). SSA region incur higher trade costs relative to other regions globally. On Average, a firm in SSA would incur US $ 604.58 to export compared to the world average of US $ 398.68. Higher trade costs hinder competitiveness of SSA's exports, hence low share in world trade.

1.1.2 Infrastructure Development by Region in Africa

In comparison to other regional economic communities (RECs) in Africa, in terms of quality and quantity, the Southern African Development Community (SADC) and the Economic Community of West African States (ECOWAS) outperform the East African Community (EAC) (African Development Bank, 2013).

Table 1.4 shows the level of Africa's infrastructure development by region. A value of 0 shows no infrastructure, while a value of 100 shows highly developed infrastructure. This implies that, the higher the index, the better the infrastructure is developed.

Table 1.4: Africa Infrastructure Development Index by Region, 2013-2019

Region	2013	2014	2015	2016	2017	2018	2019
North Africa	63.80	56.24	59.85	71.63	71.62	72.96	73.88
Southern Africa	35.15	33.34	34.54	33.47	34.97	35.46	36.96
West Africa	16.26	17.46	18.55	18.79	18.92	19.76	21.82
Central Africa	15.70	15.80	16.59	10.69	10.78	11.04	13.94
East Africa	11.58	13.85	14.61	13.52	14.00	14.60	17.51

Data Source: African Development Bank (2019)

Between 2013 and 2016, East Africa's infrastructure lagged behind other regions in Africa before slightly improving and overtaking Central Africa between 2016 and 2019 due to increased investment in infrastructure in the region particularly in transport and ICT. North Africa is the top performer in terms of overall infrastructure development, Southern Africa comes second, West Africa at the third position and Central Africa comes at fourth. The poor performance by East Africa is an indication that more investment in infrastructure is required in the region for it to be at par with others.

1.1.3 Infrastructure Development and Policy in EAC

The EAC treaty (EAC, 1999), has provisions for joint infrastructure especially in trade enhancing infrastructure such as transport and communication networks. There are joint policies that the Partner States have put in place to achieve the underlined objectives in terms of infrastructure provision. These measures are meant to encourage both intra-EAC trade and trade with other regions by eliminating the barriers in the transportation of goods and services (EAC, 2011a).

EAC Partner States have been undertaking joint infrastructure programmes in railway, roads, ports, pipeline and in energy sector. Such programmes require a high political will as shown by the Heads of State and Government Summits, which meet every two years to assess progress in implementation of these programmes and launch new ones. For instance, in the transport sector, the joint infrastructure projects are two main transport corridors to promote trade in the region. The first is the northern corridor covering 1700 km from the port of Mombasa and serves Uganda, Rwanda, Burundi, South Sudan, and Eastern Democratic Republic of Congo (DRC); including Kenya. The second is the central corridor covering

1300 km from the port of Dar es Salaam and serves Burundi, Eastern DRC, Rwanda, Tanzania, Uganda, and Zambia. Other than road infrastructure, railway infrastructure is also given a priority; this includes revamping the old railway lines to Standard Gauge Railway. The railway project is planned to cover the distance between Mombasa and Malaba, then from Kigali to Juba and finally to Bujumbura. Under communication infrastructure, the EAC has managed to boost the ICT infrastructure through four under-sea cables through the EAC Broadband ICT Infrastructure Network (EAC-BIN). This covers the East African Coast: Eastern Africa Submarine Systems (EASSY), The East African Marine Systems (TEAMS), Lower Indian Ocean Network II (LION 2) and SEACOM (EAC, 2011b).

Table 1.5 shows an index of infrastructure quality in EAC based on quality of transport and communication infrastructure between 2010 and 2019. These include roads, railway, ports, airports, electricity and mobile and fixed line communication. The index values range from $1 - 7$, where a value of 1 indicates highly undeveloped infrastructure, a value of 3.5 indicates an average development of infrastructure and 7 shows highly developed infrastructure. This implies that values below 3.5 are below average and those above 3.5 are above the average level of infrastructure development.

Table 1.5: General Infrastructure Quality Index in EAC, 2010-2019

Country/Year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Burundi	2.84	2.61	2.33	2.51	2.75	2.75	2.22	2.39	2.42	2.46
Kenya	3.76	3.89	3.98	4.38	4.35	4.16	4.30	4.30	4.45	4.52
Rwanda	4.31	4.65	4.90	4.49	4.26	4.46	4.62	4.68	4.69	4.7
Tanzania	3.01	3.12	3.10	3.16	3.15	3.13	3.52	3.59	3.62	3.64
Uganda	3.43	3.57	3.38	3.41	3.51	3.54	3.38	3.33	3.42	3.46
EAC Average	3.47	3.57	3.54	3.59	3.60	3.61	3.61	3.66	3.72	3.76

Data Source: World Economic Forum (2019)

Rwanda and Kenya are the top performing economies in EAC in terms of infrastructure; they have shown a consistent improvement in terms of infrastructure quality. Rwanda and Kenya had an average infrastructure quality index of 4.58 and 4.21 respectively between 2010 and 2019 (Table 1.5). Tanzania and Uganda had averages of 3.30 and 3.44 respectively in a similar period. Burundi is the worst performing country in EAC in terms of quality of infrastructure with an average index of 2.52, which was below the EAC average for all the years. The EAC infrastructure quality was above the average of 3.5 between 2011 and 2019.

1.1.4 Growth Trends in EAC

The growth rate in EAC region averaged 5.4 percent between 2010 and 2019 period (Table 1.6). In 2008, Rwanda had the highest growth of 11.1 percent before declining to 6.3 percent in the year 2009 due to poor weather conditions and political instability. During the same period, Kenya had the lowest growth of 0.2 percent, due to governance related problems such as the post-election violence, low international commodity prices, inadequate infrastructure relative to economic size and slow pace of reforms (Kimenyi et al., 2016). However, in terms of economic size, Kenya is the largest in EAC, followed by Tanzania, Uganda and Rwanda, with Burundi being the smallest economy.

Table 1.6 shows annual percentage growth rates based on real GDP data of the EAC Partner States between 2010 and 2019.

Table 1.6: EAC Real GDP Growth Rate, 2010-2019 (percent)

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Burundi	5.12	4.03	4.45	4.92	4.24	-3.90	-0.60	0.50	1.61	1.84
Kenya	8.40	6.11	4.56	5.87	5.35	5.72	5.88	4.81	6.32	5.4
Rwanda	7.34	7.95	8.64	4.72	6.16	8.87	5.98	3.99	8.57	9.41
Tanzania	6.34	7.67	4.50	6.78	6.73	6.16	6.87	6.79	5.44	5.79
Uganda	5.64	9.39	3.84	3.59	5.11	5.19	4.78	3.90	6.16	6.51
EAC Average	6.57	7.03	5.20	5.18	5.52	4.41	4.58	4.00	5.62	5.78

Data Source: World Bank (2019), WDI

Rwanda has been experiencing the highest growth rate in EAC, averaging 7.16 percent between 2010 and 2019. However, the neighbouring Burundi is the slowest growing country in EAC, mainly attributed to political volatility. The country recorded an average growth rate of 2.22 percent, with the country experiencing a contraction of 3.9 percent in 2015 and 0.6 percent in 2016. The rest of the countries, Kenya, Uganda and Tanzania have had stable single digit growth rates recently averaging 5.84, 6.31 and 5.41 percent respectively between 2010 and 2019. Overall, EAC growth portrays a downward trend between 2011 and 2017, with the region recording an average growth rate of below 10 percent envisaged in the EAC Vision 2050. These growth rates are relatively low given the fact that most of these countries are still less developed and would require higher growth rates to be at par with the middle-income countries of the world.

As economic theory postulates in the law of diminishing returns, additional investment in infrastructure should generate higher economic returns in LDCs with high infrastructure deficit than in countries with well-developed infrastructure systems. This phenomenon would support more financing towards infrastructure development because of the growth benefits likely to be realized (Serebrisky et al., 2015). There has been increased budgetary allocation on infrastructure by most EAC Partner States, for example in 2014, the combined value of all infrastructure projects which were to be implemented was about 70 percent of the combined GDP of the EAC countries (International Monetary Fund, 2015). Further, according to WDI of the World Bank, the value of infrastructure investments in EAC increased 10-fold, from US $ 2.2 billion in 2000, to US$ 21.6 billion in 2018. However, despite increased investment towards infrastructure in the last two decades, growth rates remain low. Thus, this study, sought to determine the effect of infrastructure stock on economic growth in EAC, with a view to generating appropriate policy implications.

1.1.5 Infrastructure and Trade in EAC

Infrastructure in the EAC region plays a central role towards the integration process, specifically in attracting foreign investors to the region, eliminating poverty, promoting regional cooperation through trade within the region and enhancing the processing of raw materials. This is aimed at making the products from the region more competitive globally hence contributing towards attainment of sustainable growth and development (EAC, 2011).

EAC emphasises on faster growth and development through trade. Table 1.7 shows the trend of trade openness[3] from the year 2010-2019. It measures an economy’s level of openness to international trade.

[3] This is given as the total imports and exports as a share of GDP

Table 1.7: EAC Trade as a Percentage of GDP, 2010-2019

Country/Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Burundi	39.5	43.0	43.7	46.6	41.8	32.5	31.7	34.4	39.2	41.9
Kenya	54.2	60.4	57.8	53.1	51.3	44.2	37.7	37.4	36.1	33.4
Rwanda	39.5	41.7	42.5	44.7	37.3	41.9	40.8	50.5	49.5	53.7
Tanzania	47.6	56.2	54.4	48.6	45.3	40.8	35.4	32.2	32.0	31.7
Uganda	38.6	40.1	43.9	43.5	36.3	38.0	31.5	36.8	36.9	46.0
EAC Average	43.9	48.3	48.4	47.3	42.4	39.5	35.4	38.3	38.7	41.3

Data Source: World Bank (2020), WDI

The trend of trade openness of the EAC Partner States as shown by Table 1.7 portrays a downward trend. The trade share of Burundi declined, from 39.5 percent in 2010 to a low of 31.7 percent of the GDP in 2016 before increasing to 41.9 percent in 2019. Kenya, Uganda and Tanzania have also shown a similar downward trend between 2010 and 2019. However, the trade share of Rwanda shows an erratic trend between 2010 and 2019. The overall EAC average trade share of GDP shows a downward trend between 2010 and 2019. Therefore, EAC Partner States have shown a downward movement in trade in the last decade, which is likely to impact negatively on economic growth. In addition, according to World Trade Organization (2019), only 6 percent of EAC's total imports are obtained from the region while intra- EAC exports constitute only 20 percent of the total. Infrastructure is one of the key factors for trade facilitation, as it increases the trade volume by lowering trade costs. The poor performance in trade by the EAC could be a problem of infrastructure; hence the need to establish how hard and soft infrastructure influences trade in EAC.

1.1.6 Institutional Quality in EAC

Better institutional quality has been associated with more bilateral trade. Alvarez et al. (2018) point out that good quality institutions imply diverse and inclusive political establishments that promote fairness with limited market abuse arising from individual economic agents through monopolistic practises and consequently limit trade due to rent-seeking actions.

Different indicators exist which are used to capture institutional quality. Worldwide Governance Indicators (WGI) of the World Bank has various indicators on institutional quality including regulatory quality, control of corruption, government effectiveness, voice and accountability and rule of law. For example, Table 1.8 presents how the EAC Partner

States performed in the control of corruption index between 2010 and 2019. The index ranges from a score of -2.5 (minimum) to 2.5 (maximum).

Table 1.8: Trend of Control of Corruption Index in EAC, 2010-2019

Country/Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Burundi	-1.2	-1.2	-1.5	-1.4	-1.3	-1.3	-1.2	-1.3	-1.4	-1.5
Kenya	-0.9	-1.0	-1.1	-1.0	-0.9	-1.0	-0.9	-1.0	-.09	-0.8
Rwanda	0.4	0.4	0.6	0.6	0.8	0.6	0.6	0.6	0.6	0.6
Tanzania	-0.5	-0.6	-0.8	-0.8	-0.8	-0.7	-0.5	-0.5	-0.4	-0.4
Uganda	-0.9	-0.9	-1.0	-1.0	-1.1	-1.1	-1.1	-1.0	-1.0	-1.2
EAC Average	**-0.7**	**-0.7**	**-0.7**	**-0.7**	**-0.7**	**-0.7**	**-0.6**	**-0.6**	**-0.6**	**-0.6**

Data Source: World Bank (2021), Worldwide Governance Indicators

Rwanda has better quality institutions with stronger anti-corruption measures compared to other EAC Partner States. The control of corruption estimate increased from 0.4 in 2010 to a high of 0.8 in 2014 before slightly declining to 0.6 in 2015. Rwanda maintained a control of corruption index of 0.6 between 2015 and 2019, indicating stable and less corruption among the public institutions. Tanzania and Kenya come second and third position in EAC with control of corruption index averaging -0.6 and -0.9 respectively between 2010 and 2019. Uganda and Burundi come at fourth and fifth with average control of corruption index of -1.0 and -1.3 respectively over the same period.

1.1.7 Defining Infrastructure

Public infrastructure is categorized into two, economic and social infrastructure. For example, roads, electricity, telecommunications, railways, ports and airports are classified as economic infrastructure as they enhance economic activities. While health and education can directly and indirectly influence the wellbeing of the society, they are classified as social infrastructure (Saidi and Hammami, 2017).

This study put emphasis on public economic infrastructure investment, specifically, investment in transport, energy, and information communication and technology (ICT), which are believed to have greater effect on trade and growth (Marazzo et al., 2010; Chi and Baek, 2013). From the literature, there is no clear and concise definition of infrastructure. Garcia et al. (2017) points out that it is very rare for researchers to use the same measurement of infrastructure and neither do they use identical type of infrastructure. Therefore, infrastructure is usually modeled as either investment (in monetary units) which is known as a ‘flow variable’ or as physical stock such as number of kilometers of roads, railways and schools, which is also known as ‘stock variable’. A different approach involves the use of principal component analysis (PCA) to develop an index for infrastructure which may be composed of different forms of infrastructure such as transport, telecommunications or even energy. Stupak (2018) further notes that, it is possible to extend the definition of infrastructure to include investments in research and development activities because they contribute to the stock of knowledge and technology which can be used by the private sector. This study adopts the use of PCA to construct an index for infrastructure stock in EAC.

1.2 Statement of the Problem

Infrastructure is crucial to a country’s growth process by initiating the process of industrialization. In the last two decades, the EAC Partner States have devoted more resources towards infrastructure development, however growth levels remain low and below the 10 percent targeted in EAC Vision 2050. While evidence on infrastructure and economic growth remains inconclusive, majority point to the positive contribution of infrastructure to growth, for example, Calderon (2009), Sahoo et al. (2010), German-Soto and Bustillos (2014), Badalyan et al. (2014) and Farhadi (2015). On the contrary, Ansar et al. (2016) found a negative link, especially in cases where infrastructure investments are debt financed and there is high investment in unproductive projects. Others such as Roller and Waverman (1996), Straub (2008), Kustepeli et al. (2012) and Crescenzi and Rodriguez-Pose (2012) concluded that growth is not influenced by infrastructure. Most of these previous studies to a larger extent did not consider infrastructure as an input in production process. Following, Calderon et al. (2011), this study complements the existing evidence by analyzing the contribution of infrastructure to EAC’s economic growth by estimating a Cobb-Douglas production function augmented for infrastructure stock.

Additionally, the contribution of infrastructure quality especially on trade flows has not been thoroughly explored by past studies such as Bensassi et al. (2014) and Ismail and Mahyideen (2015). These, among other studies focused only on a narrow range of hard infrastructure without incorporating soft infrastructure (quality of institutions). Furthermore, the volume of trade in EAC has been unstable; trade cost is a major problem to most developing countries in SSA such as the EAC Partner States. According to 2019 WDI of the World Bank, costs to export were US $ 604.58 in SSA, compared with the world average of US $ 398.68, US $

105.5 for the Euro Area, US $ 171.00 in North America and US $ 363.74 in South Asia. These statistics indicate that infrastructure in SSA explains a larger share of trade costs compared to developed countries. Trade is a key component of growth and development in an economy; however, EAC Partner States have shown a declining trend in the volume of trade with most of the countries recording a trade to GDP ratio of less than 50 percent.

The weak performance of trade in EAC is in part, due to limited product diversification and lack of a common currency and other technical barriers to trade (World Trade Organization, 2019). Nevertheless, understanding the performance of the EAC's trade requires an understanding the roles of different infrastructure types and institutional quality. Therefore, a study which investigates how infrastructure stock affects growth is necessary. More specifically, identifying the possible channels through which infrastructure influences growth such as, private investment and trade could remedy the situation. This study, therefore, complements the existing evidence on infrastructure and economic growth based on an alternative methodology, known as pooled mean group (PMG) estimator. In addition, the role of infrastructure in trade facilitation in EAC is done using both hard infrastructure and additional measures of soft infrastructure such as cost, and time taken to export and institutional variables such as regulatory quality and control of corruption.

1.3 Research Questions

This study sought to examine the following questions:

i. What is the impact of infrastructure stock on EAC's economic growth?
ii. What is the relationship between public infrastructure investment and private investment in EAC?
iii. How do infrastructure stock and institutions affect the performance of intra-and inter-EAC trade?

1.4 Objectives of the Study

This study aimed at identifying the effect of infrastructure development on trade and economic growth in EAC.

1.4.1 Specific Objectives

i. To investigate the impact of infrastructure stock on economic growth in EAC.

ii. To analyse the relationship between public infrastructure investment and private investment in EAC.
iii. To analyse the impact of infrastructure stock and institutions on intra-and inter-EAC trade.

1.5 Significance of the Study

The key aspiration of most countries is to improve the well-being of their citizens. The realization of such ambitions require adequate investment in infrastructure and sustained economic growth. This study, therefore, is useful in adding to existing literature on infrastructure development, private investment and growth, and to identify key areas for further research. It is also critical to identify the type of infrastructure which has the greatest impact on trade, which is the mission of EAC. Therefore, the findings of this study, from a policy perspective were expected to form a key resource base for policy makers in the public sector, particularly on infrastructure investment and trade facilitation.

1.6 Contribution of the Thesis

Empirical evidence on infrastructure and growth in LDCs is scanty and relatively unexplored in EAC. Specifically, no study, to our knowledge has analysed how infrastructure stock impacts economic growth in EAC based on a production function framework. In terms of measurement of infrastructure stock, the study constructed an index based on indicators drawn from transport, energy and communication sectors. Furthermore, this study used a relatively new methodology (pooled mean group estimation technique) to analyse the link between infrastructure development, growth and private investments in EAC. The superiority of PMG in estimation is its ability to control for unobserved heterogeneity and allows for both short-and long-run dynamics between infrastructure and growth. The study also investigated the direction of causality between infrastructure and growth. In addition, using the gravity model, the study introduced institutional related variables such as cost and time required to export, control of corruption and regulatory quality. On such basis, this study makes substantial contributions to the literature on infrastructure, trade and growth.

1.7 Scope of the Study

This study focused on infrastructure and growth in EAC and established the possible channels through which infrastructure influence growth such as trade and private investment.

This was conducted over the period 1990-2019 for 5 EAC Partner States, namely Kenya, Tanzania, Uganda, Rwanda and Burundi. However, due to data limitations, South Sudan, also a Partner State in EAC was not included in this study.

1.8 Organization of the Study

The study adopts an essay type format where each objective is elaborated in a separate section in the text. The first chapter introduces the entire study; describes critical issues being investigated; it highlights the objectives, significance and the study focus.

Essay number 1 focuses on link between infrastructure development and growth. It begins with an introduction of the chapter and then reviews theories linking infrastructure development and growth. Section 3 of this essay is the empirical literature which reviews past studies and identifies the possible gaps. Theoretical and empirical models linking infrastructure and growth are discussed in section 5 of this essay. Estimation results based on PMG technique are discussed in section 6 the essay. Section 7 gives a summary of the results, conclusion and policy implications.

Essay number 2 centers on the possibility of 'crowding out' of private investment in EAC, it therefore, analyses public infrastructure investment and private investment. It begins with an introduction on public and private investments. Section 2 and 3 discusses the theoretical and empirical studies on public infrastructure and private investment. Section 5 discusses the flexible accelerator investment model and the empirical model estimated. In section 6, results of estimations are presented and discussed. Finally, section 7 summarizes and concludes the findings linking public infrastructure and private investment.

The third objective is addressed in Essay number 3. It investigates the link between infrastructure and trade. It begins with an introduction linking infrastructure development and trade. It explores the trade theories and infrastructure augmented gravity model. Past studies based on infrastructure and trade are also reviewed. In the estimations, the study used both soft and hard measures of infrastructure for the period 1990 and 2019.

Chapter two summarizes the key findings of this study and concludes the entire thesis. It also highlights the policy implications drawn from the main findings.

ESSAY ONE

PUBLIC INFRASTRUCTURE DEVELOPMENT AND ECONOMIC GROWTH

2.1 Introduction

This essay begins by putting into perspective, the theories behind infrastructure development and economic growth and the possible channels. Next is a section on empirical literature, which focuses on the recent empirical studies on infrastructure and growth. Section 2.4 is an overview of the entire literature and focuses on the limitations and gaps of the previous studies. Research methodology adopted by the study and discussion of results are presented in sections 2.5 and 2.6 respectively.

2.2 Theoretical Literature

There are different contrasting theories linking infrastructure development to growth. According to Solow (1956), factor accumulation has little contribution to growth process. This means that the effect of accumulated infrastructure investment diminishes over time. Growth is mainly driven by technological progress, a factor which is determined exogenously. In this case, infrastructure investment has only level but not growth effect. Contrary to the neoclassical theory, in endogenous growth framework, capital accumulation has a significant role in long-term growth. Government spending was incorporated in Barro's (1990) growth model to show how public investment could be productive when financed by fixed income tax. The model suggest that stable business environment (law and order, government policies, infrastructure provision, and regulation of international trade) is the core determinant of long-run growth. Additionally, Romer (1987) argues that diminishing returns to factors can be suspended in an endogenous growth framework such that infrastructure investment can contribute to long-run growth. Further, in a model with steady returns to capital, increase in infrastructure stock promotes long-run growth if infrastructure is below an efficient level.[4]

Infrastructure affects growth through various channels. Public infrastructure investment can promote economic growth by encouraging private sector productivity (Aschauer, 1989; Barro, 1990; Gramlich, 1994). This is demonstrated by the idea that accrual of public capital boosts marginal productivity of factors. This results in more private sector production due to

[4] Efficient level of infrastructure is the optimum level of infrastructure that is consistent with long-run growth.

decreased cost of production hence persistent growth effect. Gramlich (1994) points out that infrastructure can simply be considered as part of the inputs in a production process. Therefore, accumulation of infrastructure stock would directly promote economic growth by increasing output of an economy. Aschauer (1989) classified non-military public capital into core and non-core infrastructure. Airports, highways, energy, sewerage and water systems are classified as core infrastructure and should explain to a larger extent, the variations in productivity. While the other category of non-military public capital such as office buildings, police and fire stations are considered as non-core infrastructure. Agenor and Moreno (2006), established that infrastructure development affects growth through complementarity and crowding-out effects. Complementarity effect occurs through accumulation of private capital. While, according to crowding-out channel, in the short-run, infrastructure investment may suppress the private sector investment, which may lower growth rates in the long-term.

Infrastructure development may also boost the productivity of other factors in a production process (Fedderke and Garlick, 2008). The productivity of capital such as machinery is enhanced by reliable energy supply. Economic growth is likely to be realized if public infrastructure is maintained at the right standards and quality; which increases the lifetime of private capital. The private sector will experience lower maintenance costs on their capital stock that makes them to invest in other areas of the economy which promotes further growth (Agenor and Moreno, 2006). The spill-over effects generated by public infrastructure may indirectly promote growth through increased foreign direct investment (FDI) inflows and trading activities (Agenor and Moreno, 2006; Fourie, 2006; Fedderke et al., 2006). Increased infrastructure development in regions with low infrastructure stock may integrate them into a national economy, encouraging private sector activities and thereby stimulate economic growth. Additionally, according to Jimenez (1995), investment in transport related infrastructure, energy and irrigation may enhance the productivity of factors used in a production process, hence higher growth in the long-run through enhanced market transactions and emergence of externalities among firms. Therefore, growth of total factor productivity (TFP) is driven by infrastructure stock and based on the assumption that, with a well-developed infrastructure, entrepreneurs can easily adopt technologies, consequently creating technical progress and economic growth.

Aschauer (1989) studied how infrastructure investment affects output in the US and made important conclusions on the contribution of infrastructure to an economy. The study concluded that states which had more infrastructure investment or high stock of infrastructure had more output, attracted large private investment and high growth in employment. This implies that economies with high stock of public infrastructure are associated with larger private sector activities. However, according to Haung and Harata (2010), the first shock in infrastructure may have a greater impact on output, thereafter a decreased effect of additional investment in infrastructure will be experienced after the construction of basic infrastructure stock in the economy. The arguments corroborate the idea by Canning and Pedroni (1999) which asserts that accumulation of infrastructure promotes long-run economic growth when a country is operating at a lower level of infrastructure.

According to Biehl (1991), increase in infrastructure stock has a direct effect on productivity and labour costs. The competitive position of a country is linked to labour costs and productivity nexus. This implies that, in situations where productivity is larger than labour costs, a country will experience inflows of capital and labour. Therefore, if productivity exceeds labour costs, infrastructure investment would result in larger economic output, hence growth. Such arguments have been supported by studies by Holtz-Eakin (1993). Similarly, Straub (2008) argues that through direct productivity channel, accumulation of infrastructure stock affects the productivity of other inputs, hence impacting on growth. Conversely, infrastructure may affect growth indirectly through different factors such as adjustment costs and labour productivity.

Improvement in infrastructure is linked to different benefits in an economy, which promotes economic growth. For example, increase in infrastructure development in a country is linked to reduced operational costs and time, increases the productivity of a given labour force and efficiency of firms. Economic activities rely heavily on the services provided by infrastructure in an economy. For instance, a well-developed transport infrastructure aids the movement of goods and services, reduces transport costs, as well as increasing accessibility to different markets (Aschauer, 1989; Gramlich, 1994). Theoretically, infrastructure is always treated as an unpaid factor of production which promotes growth; augmenting factors, thereby encouraging the productivity of labour inputs and private capital and generally acts as an incentive for firms relocation and long-run growth (Lewis, 1998).

Public infrastructure investment is expected to promote output in the short-run by stimulating demand, and in the long-term through increased general productivity (Fedderke and Garlick, 2008; Stupak, 2018). The aggregate demand channel occurs when significant resources are devoted towards infrastructure investment hence, raising the aggregate demand and stimulating output. The short-run effect on growth is largely dependent on whether infrastructure financing is through deficit or is deficit neutral, and whether the economy is in a state of recession or boom. Deficit financing has a greater potential of enhancing growth in the short-run via the multiplier effect. Specifically, as the government spends more on infrastructure, economic growth is realized as the government purchases from the private sector. However, the long-run effect on growth is also influenced to some extent, by the type of financing used. Crowding-out of private investment may occur if infrastructure investment is financed by deficit financing hence, reducing the long-run effect on output. Holding other factors constant, infrastructure investment financed under deficit neutral financing is likely to promote long-run economic growth because they do not suppress private investment. However, in the short-run, deficit-neutral projects have negligible effects on output. The type of infrastructure also matters for growth, as investment in economic infrastructure have higher economic returns in comparison to social infrastructure (Stupak, 2018).

According to Ansar (2016), high investment in infrastructure with little returns can result in negative consequences in an economy especially if it is debt financed. That is, large investment in infrastructure projects that are underutilised and unproductive can lead to economic and financial crisis. This can result in sovereign debt overhang, high monetary growth, financial market instabilities and economic vulnerability.

The short-run effect of infrastructure investment on output also depends to a larger extent, on the timing of the business cycle (Auerbach and Gorodnichenko, 2012). As postulated in economic theory, the effect on growth of any public investment made during recession will be greater than if similar investments were made during a period of boom. This is due to underutilization of capacity during recession and therefore, any investment by the government is expected to generate higher returns on output because the idle capacity will be utilized in production. Whereas, due to limited capacity experienced during economic expansion, any public investment undertaken may produce limited economic gains in terms of output. Further, according to Stupak (2018), if such investments are made when there is full employment, then higher levels of inflation may be experienced and anti-inflationary policies that may be employed by the government are likely to lower the short-run output gains.

2.3 Empirical Literature

Kodongo and Ojah (2016) used system generalised method of moments approach to uncover the link between infrastructure and economic growth using a growth model for a sample of 45 SSA countries between 2000 and 2011. They found that increases in access to infrastructure and spending on infrastructure influence economic growth in SSA. However, they concluded that infrastructure quality and stock do not inform growth in SSA. They link this to the nature of infrastructure network in most African countries which are concentrated in urban areas and not accessible to majority of the population hence limiting participation in economic activity. This contrasts the findings by Chakamera and Alagidede (2017) that analysed how infrastructure stock and quality affects growth for 43 SSA countries using data covering the period 2000 and 2014. By employing generalised method of moments (GMM) to control for endogeneity, their findings reveal that infrastructure stock drives growth in SSA while quality effect is weak. In addition, they found a uni-directional causality from infrastructure to growth.

Similarly, Calderon (2009) used an instrumental variable (IV) technique for a sample 136 countries and data covering the period 1960 to 2005. The study found that infrastructure services promote growth in Africa. Specifically, boosting the stock of infrastructure in East Africa to the standards of Mauritius with an index of 1.02 has the potential of increasing growth rate by 2 percent annually. German-Soto and Bustillos (2014) investigated the contribution infrastructure investment to Mexico's economic growth using data for urban areas for a 23-year period. By estimating a production function, they established that infrastructure investment and growth have a long-term relationship, and that faster growth is experienced in areas with more infrastructure provision.

Other panel studies supporting findings by Calderon (2009) include Romp and de Haan (2005), who in their 32 of 39 Organization for Economic Co-operation and Development (OECD) countries studied found that infrastructure enhances economic progress. Straub and Terada-Hagiwara (2011) studied a panel of 102 developing countries between 1971 and 2006. Using IV, fixed effects and growth accounting approaches, they found that growth is accelerated in East- and South Asian nations through increased infrastructure stocks. However, their growth accounting findings reveal positive effect on total factor productivity in only three countries[5] and only for electricity and telecommunications indicators. In addition, they noted that many countries do not have adequate finance to fund the required infrastructure stocks.

By applying static and dynamic panel regression techniques to determine the contribution of transport infrastructure to economic progress in the European Union (EU) over the period 1990-2004, Crescenzi and Rodriguez-Pose (2012) established that infrastructure has very minimal effect on EU growth. They found that sufficient social filter, regional ability to innovate and the extent to which immigrants can be attracted to the region explain economic progress in the EU. They used the number of kilometres of the highways as a proxy for infrastructure in the transport sector in 120 regions of the EU. Badalyan et al. (2014) conducted a similar study in Georgia, Armenia and Turkey between 1982 and 2010 using vector error correction mechanism. They found that in the short-run, goods transported by roads and railway spur economic growth; implying that transport infrastructure propels growth for the panel of countries studied. This clearly contradicts the findings by Crescenzi and Rodriguez-Pose (2012).

By employing a Cobb-Douglas production function for 28 provinces to determine the role of investment in transport infrastructure in propelling China's economic growth between period 1978 and 2008, Yu et al. (2012) estimated a fixed effects model and established varied contributions of transport infrastructure to economic growth. That is, on one hand, for regions with established transport facilities, additional investment in transport infrastructure generates diminishing returns to output. On the other hand, more investment in regions with infrastructure deficiency does not guarantee higher returns to output. This is because, if newly established transport networks are underutilized, then economic benefits of the transport network will not be realized, implying that slow growth can still be experienced even with increased infrastructure investment. This is in complete contrast to a study by Demurger (2001) who argues that more economic benefits of additional infrastructure investment will be realized in regions that have deficit infrastructure than in regions with well-endowed infrastructure networks. The study sampled 24 Chinese provinces to establish the contribution of infrastructure investment to economic growth between 1985 and 1998. To ensure robust results, the study employed two-stage least squares, fixed and random effects models and found that transport infrastructure stock and economic growth have a concave

[5] The three countries are: Thailand, republic of Korea and the People's Republic of China (PRC).

and non-linear relationship. Moreover, the positive contribution of transport facilities diminishes with development.

Similar studies supporting the fundamental contribution of transport infrastructure to growth process include Melo et al. (2013) who particularly emphasized that roads have higher returns in comparison to other forms of transport such as ports, airports and railways. They employed a meta-regression model involving 563 estimates from 33 studies to establish the extent of transport elasticity of output. They also found that transport elasticity of output is lower in the European nations compared to United States. They link this to higher dependency on road transport in the United States in comparison to Europe. The authors further emphasize that transport infrastructure tends to affect economic growth more significantly in the long-term than in the short- or medium-term.

Studies from single country studies include Sahoo et al. (2010) who used auto-regressive distributed lag (ARDL) and generalised method of moments (GMM) methods for a 22-year period (1975 -2007) in China. They established that infrastructure stock is critical to China's growth in the long-run. Furthermore, their causality results show a uni-directional causality from infrastructure to growth. Contrary to these findings, Ansar et al. (2016) argue that increased infrastructure spending does not always guarantee growth. They did a cost-benefit analysis using data for 95 Chinese road and rail infrastructure projects covering the period 1984 to 2008. Over-investment in non-useful infrastructure[6] can instead result into financial and economic crisis. They further emphasize that, for China, lack of well administered public projects are the main reasons for emerging financial and economic crises.

Other studies have also found no significant contribution of infrastructure development to growth. Kustepeli et al. (2012) used causality and cointegration analysis to investigate how international trade and growth in Turkey were affected by spending on highway infrastructure between 1970 and 2005. They found no significant contribution of increased spending on highway infrastructure to international trade and economic growth in the long-run. Straub et al. (2008) used data covering the period 1971 to 1995 and found that infrastructure investment plays no role in influencing growth and productivity in 16 East Asia and Pacific countries when they used a growth-accounting framework. They further applied cross-country regressions using ordinary least squares (OLS), fixed and random effects and two-

[6] Non-useful infrastructure refers to infrastructure projects which do not yield the intended benefits. Their benefits cost ratio is normally less than 1. Such projects normally result in macroeconomic instability (Ansar et al., 2016).

stage least squares and found that infrastructure has negative effect on LDCs and positive effect on developed countries. They argue that high income countries provide a favourable environment that gives the necessary conditions for infrastructure investment to yield positive results in an economy.

Contrary to the findings by Kustepeli et al. (2012) and Straub et al. (2008), Pradhan and Bagchi (2013) estimated a vector error correction model for 1970- 2010 period to uncover the role of transport infrastructure in India’s growth. They established bi-directional causality between road transport infrastructure and growth. Supporting the findings by Pradhan and Bagchi (2013), is a study of 18 OECD countries by Farhadi (2015) that used GMM to correct for endogeneity bias and unobserved heterogeneity. The study used data covering the period 1870 to 2009 to determine the link between transport infrastructure and long-run growth. The findings established that a rise in infrastructure spending by 10 percent increases labour productivity by 0.14 percent in OECD. In a similar study, Roller and Waverman (1996) studied the connection between telecommunications investment and growth for 35 countries using data covering 1970 to 1990. They jointly estimated a micro-model with macro-growth equation using a fixed effects model. They found decreased effect of telecommunications infrastructure on growth when simultaneity and country specific fixed effects are controlled for. They also argued that increased stock of telecommunications infrastructure could generate more growth effects in OECD compared to LDCs.

2.4 Literature Overview

The theoretical foundations on public infrastructure and output in the Aschauer (1989) model used time series data in a Cobb-Douglas production function framework. The application of aggregate time series data in such kind of a study has associated statistical problems which are likely to arise. This includes a spurious relationship between the explanatory variables in production (inputs) and output which may be created by the type of data used since they all grow with time. Another problem arises due to the time lags between public infrastructure development and their use by the private sector producers. This would result in unreliable estimates in relation to productivity due to time series data. However, like in Lynde and Richmond (1992), such statistical problems can be solved by use of more superior time series analysis techniques such as error correction mechanism (ECM) and cointegration analysis, which are employed in this study.

In general, most studies support the positive contribution of infrastructure to economic growth. However, a detailed literature review indicates that this link has not been unanimously accepted. This implies that, evidence on infrastructure and growth has produced mixed results; some support the idea that infrastructure development promotes growth (Romp and de Haan, 2005; Calderon, 2009; Sahoo et al., 2010) and Straub and Terada-Hagiwara, 2011). Others support the idea that infrastructure development does not significantly influence growth (Ansar et al., 2016; Kustepeli et al., 2012; Straub, 2008 and Roller and Waverman,1996). The differences in the findings could be linked to the nature of data used, differences in geographical locations, different econometric methodologies and economic models estimated. Straub (2011) further emphasizes that because of differences in scope (time periods and samples under study) and econometric tools applied; it is not possible to compare the results as such. Therefore, whether infrastructure promotes economic growth or not, is subject to empirical investigation. This study, therefore, sought to determine how infrastructure development affects economic growth in EAC by employing a relatively recent alternative estimator, the PMG.

The type infrastructure indicator used also determines the type of results obtained. There are two main types of indicators used in literature: infrastructure as a flow variable (infrastructure investment) and as a stock variable (physical indicators of infrastructure). Studies that use investment as indicator for infrastructure tend to get varied results, for example, Straub (2008), Yu et al. (2012), German-Soto and Bustillos (2014), Ansar et al. (2016) among others. This is because, as pointed out by Pritchett (1996; 2000), cumulated investment flows may not be a true reflection of the exact capital stocks, as the cost of such investments may possibly differ from their values. Kenny (2009) links such outcomes to potential corruption which is rampant in most infrastructure projects and other government inefficiencies. On the other hand, most studies that use physical indicators tend to get positive effect infrastructure on output, for example, Aschauer (1989), Calderon (2009), Sahoo et al. (2010), Straub and Terada-Hagiwara (2011) and Melo et al. (2013).

In terms of econometric methodologies that have been applied, some authors have employed the IV technique to establish the effect of infrastructure on output such as Calderon (2009). Others such as Kustepeli et al. (2012) and Badalyan et al. (2014) have respectively used causality and cointegration and vector error correction techniques. To control for possible endogeneity problems, studies by Kodongo and Ojah (2016) and Sahoo et al. (2010)

employed the GMM technique. Lastly, a number of studies have used panel static and dynamic techniques. This implies that few studies have used panel time series methods such as the PMG estimator. Therefore, as a contribution to the existing literature, this study employed a PMG technique to establish the contribution of infrastructure in driving EAC's growth in a production function framework. The PMG estimator allows for both short-and long-run dynamics.

No study, to our knowledge, has uncovered the contributions of infrastructure development and growth in EAC. This study, therefore, adds to the existing evidence by examining the link between infrastructure stock and economic growth in EAC by constructing infrastructure stock index and employing a more superior methodology, a panel time series estimator, PMG. In addition, the nature of causality between infrastructure and economic growth is not well known, hence investigated in this study.

Table 2.1 summarizes some of the previous studies on infrastructure and growth. It gives the type of data used, methodology employed and key findings.

Table 2.1: Summary of Key Studies on Infrastructure and Growth

Authors	**Data Type and Sample**	**Model/Methodology**	**Infrastructure Variable**	**Findings**
Roller and Waverman (1996)	Panel data for 35 countries. Period 1970-1990	Fixed effects model	Investment in telecommunications infrastructure	Decreased effect of telecommunications infrastructure on growth
Demurger (2001)	Panel data for 24 Chinese provinces. Period: 1985-1998	Fixed effects, random effects and two-stage least squares	Roads, railway and inland navigable water network per square kilometer and telephone sets per capita	Positive effect of transport facilities diminishes with development
Straub et al. (2008)	Panel data for 16 East Asia and pacific countries. Period: 1971-1995	Growth Accounting. OLS, two-stage least squares, fixed- and random-effects	Number of telephone main lines, electricity generating capacity and total roads	Infrastructure investment plays no role in promoting growth and productivity in East Asia

Calderon (2009)	Panel data for 136 countries. Period: 1960-2005	IV	Infrastructure index: telecommunications, electricity and roads	Infrastructure quantity and quality promotes growth
Sahoo et al. (2010)	Time series data for China. Period: 1975-2007	GMM and ARDL	Infrastructure stock index based on: energy use per capita, mobile and fixed telephone, railway, paved roads and air transport	Infrastructure stock supports China’s growth in the long-run
Straub and Terada-Hagiwara (2011)	Panel data for 102 developing countries. Period: 1971-2006	IV, fixed effects and growth accounting.	Telecommunications, electricity and railroads	Increased infrastructure stocks accelerate growth in East Asia-Pacific and South Asia nations
Crescenzi and Rodriguez-Pose (2012)	Panel data for EU. Period: 1990-2004	Two-way fixed effects and difference GMM	Kilometres of highways	Infrastructure has very minimal effects on EU growth
Yu et al. (2012)	Panel data for 28 provinces in China. Period: 1978-2008	Fixed effects model	Constructed transport infrastructure stock from transport infrastructure investment	Increased investment in transport infrastructure generates diminishing returns to output in regions with well-endowed transport network
Kustepeli et al. (2012)	Time series data for Turkey. Period: 1970-2005	Granger causality and cointegration	Public investment on highway transport and length of highways in kilometres	Increased spending on highway infrastructure does not impact long-term growth
Melo et al. (2013)	563 estimates from 33 studies	Meta-regression model	Transport infrastructure: roads, railway, airports and ports	Roads generate higher returns on output than other modes of transport

Pradhan and Bagchi (2013)	Time series data for India. Period: 1970-2010	VECM	Road and railway	Bi-directional causality between road infrastructure and growth
Badalyan et al. (2014)	Panel data for Armenia, Georgia and Turkey. Period: 1980-2010	Vector error correction mechanism: Dynamic and fully-modified OLS	Goods transported, and passengers carried via rail and roads, and rail and road network in kilometres	Transport infrastructure drives growth
German-Soto and Bustillos (2014)	A panel of 71 cities in Mexico. Period: 1985-2008	Panel cointegration	Roads, electricity and water supply	Faster growth is experienced in areas with more infrastructure provision.
Farhadi (2015)	A panel of 18 OECD countries. Period: 1870-2009	GMM	Infrastructure stock from investments in roads, highways, airports, railways and inland waterways	Transport infrastructure and labour productivity are positively linked.
Kodongo and Ojah (2016)	Panel data for 45 countries in SSA. Period: 2000-2011	SGMM	Infrastructure development index: electricity, transport, ICT and water and sanitation	Infrastructure quality and stock do not inform growth in SSA.
Ansar et al. (2016)	Time series data for China. Period: 1984-2008	Cost-benefit analysis	Railway and roads	Over-investment in unproductive infrastructure leads to macroeconomic instability, especially if debt financed.

2.5 Methodology

This section discusses the theoretical framework upon which this essay is founded. It also describes the empirical model employed in the estimation.

2.5.1 Theoretical Framework

On a theoretical perspective, infrastructure directly affects output as a factor input and indirectly through technological progress. Following Gramlich (1994) and literature on infrastructure and growth as highlighted in a survey by Straub (2011), the general idea involves expansion of an aggregate production function to accommodate infrastructure capital. A standard approach to include infrastructure capital in a growth model involves introducing public capital as one of the inputs in a production function (Calderon et al., 2011). The general production function is presented as:

$$Y = AF(K, L) \tag{2.1}$$

Where

Y is real gross output,

A is technology,

K is non-infrastructure capital (private capital),

L is labour force

In equation 2.1, Aschauer (1989) and other authors consider A as a function of services provided by public capital. By augmenting Cobb-Douglas production function to incorporate the stock of intermediate inputs as part of the production process, together with labour and capital by the private sector, the following production function is obtained:

$$Y = A\,.\,F(K, L, I(K_{PI})) \tag{2.2}$$

Where

K_{PI} is public capital/infrastructure stock.

$I(K_{PI})$ is intermediate input variable

Like in the Solow (1956) growth model, Equation (2.2) can also be subject to constant returns to scale (CRS). According to Hulten et al. (2005), improved public infrastructure (K_{PI})

reduces cost of associated intermediate inputs through market-mediated effect of infrastructure.

Contrary to the usual considerations in literature, Romp and de Haan (2005) give some reasons why public infrastructure affects the production function indirectly through the intermediate inputs and not directly as an additional input in production process. First, adding K_{PI} directly into the production function implies that infrastructure has features of a public commodity and creates services proportionate to infrastructure. However, since infrastructure is progressively mediated through markets like private goods, it is therefore necessary for infrastructure to enter firms' production function as specified in Equation (2.2) via production of specific services such as transport and ICT. Second, even with rising market mediation of infrastructure, evidence shows that its costing and pricing do not reflect the basics of such activities, hence, it is unlikely that such kind of capital is compensated the value of its marginal product irrespective of whether the assumptions of CRS are upheld.

Duggal et al. (1999) points out that it is not possible to price a unit of infrastructure, hence it becomes questionable to include as it one of the inputs in a production process, since firms will be unable to make proper choices on the price infrastructure quantities utilised by them. According to a survey by Straub (2011), this has resulted in many authors considering infrastructure as part of the TFP term A, since it acts by reducing costs and enhancing economies of scale through market expansion, all of which have effects on productivity. Taking this into account, Equation (2.2.) now becomes:

$$Y = A(\varphi, K_{PI}) \,.\, F(K, L, I(K_{PI})) \tag{2.3}$$

Equation (2.3) implies that changes in the TFP term A can result from two sources: accumulation of infrastructure capital (K_{PI}), which may lead to efficiency-enhancing externalities, and other sources of efficiency-enhancing externalities (φ). It can, therefore, be concluded that infrastructure affects output directly via intermediate inputs. This is known as direct effect of infrastructure and indirectly through the efficiency enhancing infrastructure, which is known as indirect effects.

Both endogenous growth theory by Romer (1990) and new economic geography by Krugman (1994) highlight some of the externalities related to infrastructure. For example, the supply of reliable and quality energy can make firms use more advanced machinery and well-developed transport infrastructure can result in economies of scale, more competent inventory management and agglomeration economies due to reduced transport costs [7] (Baldwin et al., 2003; Hulten et al., 2005).

Following Barro (1991), assuming a general Cobb-Douglas type of production function and ignoring other sources of productivity growth gives us equation 2.4:

$$Y = (A \, . K_{PI}^{\tau}) \, F(K, L, K_{PI}) \tag{2.4}$$

Where

$(A \, . K_{PI}^{\tau})$ is the productivity term

τ is elasticity of productivity term with respect to infrastructure capital

Equation (2.4) has been written with infrastructure capital entering the production function directly as additional input factor.

From equation (2.4), it can be deduced that:

$$A = (A \, . K_{PI}^{\tau}) = A^{*} \tag{2.5}$$

From equation (2.5), equation (2.4) can be rewritten as:

$$Y = A^{*} F(K, L, K_{PI}) \tag{2.6}$$

Log-linearizing (2.6) gives:

$$lnY = lnA^{*} + \alpha lnK + \beta lnL + \delta lnK_{PI} \tag{2.7}$$

Where

α, β and δ are production elasticities.

Assuming that labour and private capital are paid their marginal products and if $\delta > 0$, $\alpha + \beta = 1$ and $\alpha + \beta + \delta > 1$, then this implies increasing returns to scale. However, if there is CRS and δ is positive, with capital and labour being paid more than their marginal products, then $\alpha + \beta + \delta = 1$ and $\alpha + \beta < 1$.

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[7]Transport costs incurred during transportation of goods generally include fuel consumption, costs incurred in using toll roads and time related costs.

Equation (2.7) can be used to establish the rate of return on public capital. By differentiating equation (2.6) in its Cobb-Douglas form gives:

$$\frac{\partial Y}{\partial K_{PI}} = F_{K_{PI}} = \delta A K^{\alpha} L^{\beta} K_{PI}^{\delta-1}$$

$$\delta = \frac{F_{K_{PI}} K_{PI}}{A K^{\alpha} L^{\beta} K_{PI}^{\delta}}$$

$$\delta = \frac{F_{K_{PI}} K_{PI}}{Y} \tag{2.8}$$

Where

$F_{K_{PI}}$ = marginal product of public capital.

In determining optimal stock of infrastructure for a country, Straub (2011) further simplified the Cobb-Douglas production function given as:

$$Y = A.\ K^{\alpha}.K_{PI}^{\delta}\ .L^{1-\alpha-\delta} \tag{2.9}$$

From Barro (1991), under the assumption that infrastructure investment is a constant proportion γ of aggregate savings, the efficient level of infrastructure investment which maximizes growth can be given by $\gamma^{*} = \delta/(\alpha+\beta)$. Canning and Pedroni (2004) further demonstrate that adding stochastic disturbances ε_t to productivity and infrastructure investment over time leads to changes in output. That is, if $\gamma_t = \bar{\gamma} + \varepsilon_t$, then a positive shock to infrastructure investment will promote growth as long as $\bar{\gamma} < \gamma^{*}$, and lower growth if $\bar{\gamma} > \gamma^{*}$. This, therefore, implies that diverting resources from other productive uses reflect marginal cost of increased investment in infrastructure, while the gains in long term growth reflect the marginal benefits.

In literature, the indirect effect of infrastructure through the technological progress is usually ignored. This implies that the infrastructure is mainly considered as having a direct effect on output as an input factor. However, under endogenous growth theory, the model can experience either constant or increasing returns to public or private capital (Romer, 1987).

The endogenous and neoclassical theories have different explanations on how infrastructure affects growth in the long-run (Sahoo et al., 2012). Under exogenous growth framework, long-run growth results exclusively from technological progress which drives long-run growth, therefore, infrastructure has only the level effects. However, changes in infrastructure level can promote growth within an endogenous growth framework.

2.5.2 Empirical Model

The role of infrastructure in explaining real GDP growth is described in a production function framework. This implies that the study adopts an aggregate production function augmented for infrastructure. Of particular interest to this study is the effect of infrastructure capital on growth and not non-infrastructure capital. Therefore, the following growth model was estimated with inputs comprising of public infrastructure capital (infrastructure index), non-infrastructure capital, and labour, covering the period 1990-2019.

$$\ln Y_{i,t} = \beta_0 + \beta_1 \ln INFR_{i,t} + \beta_2 \ln K_{i,t} + \beta_3 \ln L_{i,t} + \mu_i + v_t + \varepsilon_{i,t} \quad (2.10)$$

Where

$Y_{i,t}$-Real GDP; $INFR_{i,t}$-Infrastructure stock variable; $K_{i,t}$- Non-infrastructure capital stock; $L_{i,t}$- Labour force; μ_i– unobserved country-specific effects; v_t–unobserved time-specific effects;

$\varepsilon_{i,t}$– is the error term which is assumed as not correlated across countries and over time.

$i = 1,2,\dots,N$ –is the number of countries in the panel

$t = 1,2,\dots,T$ –is time period, which gives the total number of observations over the period

2.5.3 Variable Definitions and Expected Signs of their Coefficients

Real GDP: It refers to the total value of a country's domestic production in a given year. In this model, it is the dependent variable and used to measure economic growth of a given country.

Infrastructure Stock[8]: It refers to the total quantity of infrastructure in a country as constructed using PCA methodology. Infrastructure development according to theory is regarded as a component of physical capital in an economy (Aschauer, 1989). Infrastructure

[8] Infrastructure capital is obtained by constructing an index based on the physical measures of infrastructure such as kilometers of railway and roads, amount of installed electricity generating capacity in Megawatts and telephone/mobile users. The value of the infrastructure stock ranges from -5 (minimum infrastructure stock) and 5 (maximum infrastructure stock). Data for the variables covers the period 1990-2019 and is obtained from the National Bureau of the Partner States and AfDB Socio-Economic Database (see Table 2.2).

stock changes affect national output and directly stimulate economic growth. Barro (1990) argues that infrastructure complements other factors of production implying that infrastructure may improve TFP by lowering the cost of inputs. Therefore, in this study, infrastructure was expected to boost economic growth.

Capital Stock[9]: Accumulation of physical capital stock in an economy occurs through investments in new machinery, factories and other equipment. High capital stock enhances the possibility of more output through increased production. Capital accumulation is a fundamental source of growth especially at early stages of economic growth (Krugman, 1994). During these stages, a high rate of investment has a greater contribution to economic growth than TFP. On the other hand, King and Rebelo (1993) argue that physical capital accumulation only has a modest role in a growth process. In the context of EAC countries, physical capital should positively contribute to economic growth.

Labour Force: It is the number of people supplying labour for production of goods and services per year. Large labour force in terms of size is likely to promote growth as it enhances absorption of new ideas by a country and products that have been discovered elsewhere (Nelson and Phelps, 1966). Similar sentiment is made by Romer (1990) who argues that investment in quality labour force creates ideas or products which enhances technological progress. In addition, faster rate of introduction of new goods is likely to promote rapid growth in countries with larger and well-developed labour force. Skilled and unskilled labour force would contribute differently to growth and disaggregating the labour force data is desirable. However, due to data constraints, aggregate labour force is used in this study. Labour force was therefore, predicted to enhance economic growth in this study.

2.5.4 Variables Measurement and Sources of Data

The study involves a panel of 5 Partner States covering a 30-year period, 1990-2019.

As a measure for the overall level of infrastructure development, this study uses economic infrastructure measures from transport, energy and communication sectors. Physical infrastructure comprises of several individual ingredients. The ingredients in this study refer to, for example transport infrastructure, energy infrastructure and communication infrastructure. An ingredient from an individual sector alone is inadequate to guarantee a

[9] Perpetual inventory method is used to construct capital series using data on GFCF obtained from WDI of the World Bank (See Appendix A for details).

good pointer of the level of infrastructure stock in a country. For example, an economy may be endowed with a good transport network but with unstable energy supply. As such, an indicator relying on a good transport network by itself would give a wrong impression about the level of overall physical infrastructure in an economy. It is therefore upon such arguments and data availability considerations that transport, energy and communication sectors were chosen in this study. The composition of each of the infrastructure sectors is described as:

(i) Transport infrastructure- this was captured by length of road network and railway lines and measured in kilometers. However for robustness checks, the study also uses the total road network, paved and unpaved and the railway network in kilometers, which are combined as a proxy for transport infrastructure.

(ii) Energy infrastructure- this was measured by the total electricity generating capacity (EGC) in Megawatts (MW). This refers to all sources of electricity generation including hydro, thermal oil, geothermal, wind, co-generation and solar.

(iii) Communication infrastructure- this is given as number of fixed telephone lines per 1000 inhabitants and mobile phone subscribers per 1000 inhabitants. That is, the total number of fixed telephone lines captures the communication infrastructure; however, for purposes of conducting robustness checks, the study also combined both measures as an alternative measure for communication infrastructure.

(iv) Physical capital-this is obtained using perpetual inventory method [10] with data on gross fixed capital formation (GFCF) obtained from the WDI of the World Bank.

Table 2.2 describes the variables used in the estimations, their measurements and sources of data.

[10] For details on perpetual inventory method (PIM), see Appendix A.

Table 2.2: Variable Definitions, Measurement and Sources of Data

Variable	Measurement	Data Source
Real GDP per Capita	Measured at constant 2010 US$	World Bank (WB), WDI (2020) Data Base
Paved Roads	Total length in kilometers of the road network (paved) in a country.	National Bureau of Statistics of Partner States and East Africa Facts and Figures
Total Road Network	The total length of roads in a country, measured in kilometers	African Development Bank (AfDB) database and East Africa Facts and Figures
Railway line	Total route of the railway line in kilometers	WB, WDI (2020) Data Base
Energy	Measured in gigawatt hours of installed capacity	National Bureau of Statistics of Partner States and AfDB Socio Economic Database, 1960-2021.
Main Telephone Lines	Measured by number of main telephone lines per 1000 inhabitants	AfDB Socio Economic Database, 1960-2021.
Fixed Lines and Mobile Phone Subscriptions	Number of telephone lines in a country or aggregate number of mobile and main lines per 1000 inhabitants	AfDB Socio Economic Database, 1960-2021.
Gross Fixed Capital Formation	Measured at 2010 US$	WB, WDI (2020) Data Base
Physical Capital	The study uses GFCF to construct a series of physical capital stock, measured in 2010 US$	Constructed using the perpetual inventory method using data on GFCF obtained from WB, WDI (2020) Data Base
Labour	The number of people aged between 15 – 64 years supplying labour to produce goods and services	WB, WDI (2020) Data Base

2.5.4.1 Constructing Infrastructure Index

To come up with the desired infrastructure index based on transport, energy and communication sectors, this study employs the PCA method. PCA is a multivariate technique where data is reduced to preserve only key information (Davo et al., 2016). Therefore, PCA takes important details from a given set of data and expresses it as a new set of orthogonal variables (Abdi and Williams, 2010). Further, PCA makes data easy to analyse (Unglert et al., 2016).

PCA involves analyzing a matrix Z of order *IK*, where *I* refers to the number of rows, which represent observations and *K* refers to the number of columns, which represent the number of variables. Therefore, element Z_{ik} refers to an observation *i* in the *k* dimensional space. The matrix *Z*, consisting of *I* rows defines the infrastructure data set, while *K* defines the three different types of infrastructure sectors in each Partner State. PCA is used to aggregate the three different forms of infrastructure stock, transport (K_1), energy (K_2), and communications (K_3). PCA is therefore, used to determine the principal components among which variance is the greatest.

The first principal component P_1 is a linear combination of standardized infrastructure indicators, $Z_1, Z_2, \dots, Z_3$, which is given as:

$$P_1 = w_1 Z_1 + w_2 Z_2 + \cdots + w_n Z_n \tag{2.11}$$

Where

$w = (w_1, w_2, \dots, w_n)$ refers to vector of weights.

Maximum variance can be obtained from Equation 2.11 for any possible choice of weights provided that sum of squares of the normalized weights is equal to 1, implying that $w'w = 1$ (Calderon, 2009). A new variable P_1 created gives a good description of the variables *Z* provided that the variance is large. This can only be attained by finding the optimal weights, $w_1, w_2, \dots, w_n$, that maximize the variance.

The optimal weights (w_i, $i = 1, 2, \dots, n$) are obtained based on the different data sets on infrastructure. The weights that maximize variance of P_1 are the elements of the i^{th}Eigen vector linked to the maximum variance of P_1. Therefore, the weights for the first principal component are obtained from the Eigen vector that has the largest Eigen value.

The next step is to obtain the principal components that contain the most important information about the infrastructure sectors. The principal components are such that the first one contains the most information and explanation of the data set, and then followed by others in a similar criterion, implying that they are ordered by level of importance.

The first principal component is given by the index IS_1, which is composed of the information from total number of kilometers of road network, electricity generating capacity in gigawatts, and main line and mobile phone subscriptions per 1,000 inhabitants. The other index for robustness checks is given by IS_2, it combines both telephone lines and mobile phone subscriptions instead of the main lines only.

The first indicator IS_1 comprises of road network in kilometers, electricity generating capacity and main line and mobile phone subscriptions per 1,000 inhabitants is the preferred one as it accounts for about 70 percent of the total variance. It is therefore, used as an indicator for infrastructure stock and used in the regression model as an infrastructure variable.

2.5.5 Key Econometric Issues

2.5.5.1 Cross-Sectional Dependence

When dealing with macroeconomic data involving different cross-sections, a test for cross-sectional dependence (CD) is necessary to avoid inefficient and invalid estimates. Hence, testing for CD is required before conducting other empirical tests. Pesaran (2004) developed a test for CD which is employed in this study. It is modeled as:

$$y_{it} = \alpha_i + \beta_{it} x_{it} + \mu_{it} \tag{2.12}$$

Where:

$\alpha_i -$ time invariant individual parameters

$\beta_{it} - K \times 1$ vector of parameters

$x_{it} - K \times 1$ vector of regressors

$\mu_{it} -$ is independently and identically distributed, $i = 1,2, \dots, N$ and $t = 1,2, \dots, T$

The test assumes a null-hypothesis of no correlation of residuals from different cross-sectional units (no CD) against an alternative hypothesis that the residuals are correlated. These are given as:

$$H_0: \sigma_{ij} = \sigma_{ji} = cor(\mu_{it}, \mu_{jt}) = 0 \;\; for\; i \neq j$$

$$H_1: \sigma_{ij} = \sigma_{ji} \neq 0 \;\; for\; some\; i \neq j$$

Where:

$$\sigma_{ij} = \sigma_{ji} = \frac{\sum_{t=1}^{T} \mu_{it}\mu_{jt}}{(\sum_{t=1}^{T} \mu_{it}^2)^{\frac{1}{2}}(\sum_{t=1}^{T} \mu_{jt}^2)^{\frac{1}{2}}} \qquad (2.13)$$

An alternative test, is Breush-Pagan (1980) Lagrange Multiplier (LM) test of independence is given by:

$$LM = \sum_{i=1}^{N-1} \sum_{j=1+1}^{N} T_{ij}\, \hat{\sigma}_{ij}^2 \rightarrow \chi^2 \frac{N(N-1)}{2} \qquad (2.14)$$

Where $\hat{\sigma}$ is a correlation coefficient obtained from the residuals of the model. A different test that strengthens the LM test is by Pesaran (2004) which involves averaging the value of pairwise correlation coefficients $\hat{\sigma}_{ij}$from the residuals of the Augmented Dickey-Fuller (ADF) regressions which is given as:

$$CD_{LM} = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=1+1}^{N} \hat{\sigma}_{ij} \rightarrow N(0,1) \qquad (2.15)$$

The superiority of this test in terms of performance in small samples was verified by Pesaran (2004), and therefore relevant for this study.

2.5.5.2 Problem of Reverse Causality

Another likely problem that has been mentioned in past studies by Calderon et al. (2011) and German-Soto and Bustillos (2014), is the potential reverse causality. This is where infrastructure development might cause economic growth. Likewise, high economic growth might necessitate the need for more infrastructure services. That is, high income or advanced economies might invest more in infrastructure hence infrastructure development. Calderon et al. (2011) emphasize the need to control for such forms of reverse causality as failure to address such a problem might lead to upward biases. To address the problem, this study tests for common cointegrating relationship amongst the variables in the model. In addition, this study also conducts a test for Granger-causality.

2.5.5.3 Potential Heterogeneity across Countries

Heterogeneity refers to variation across the cross-sectional units of observations. In this case, it is the differences among countries in a panel which could arise from various factors such technological endowments. Because the variation cannot be observed, it is usually referred to as unobserved heterogeneity. It is a common phenomenon for studies that use panel data to experience heterogeneity. In this study, there is a possibility for emergence of heterogeneity across the 5 EAC Partner States specifically in output-elasticity of infrastructure due to different infrastructure endowments and technological features. A solution to heterogeneity is to allow for short-run heterogeneity and by testing for homogeneity in the long-run relationship (Calderon et al., 2011). This study used Hausman test to test for both individual and joint parameter homogeneity. The PMG estimates are preferred and more efficient in comparison to a mean group (MG) if homogeneity is detected in the parameters; otherwise the MG estimator is preferred. That is, the null hypothesis shows that the PMG estimator is preferred.

2.5.5.4 A Measure of Infrastructure

As highlighted earlier in this study, there is no precise definition and measure of infrastructure. The use of monetary measures to infrastructure might not be accurate (Pritchett, 1996, 2000; Calderon et al., 2011). This study uses the physical measures of infrastructure to address the problem. Infrastructure index is constructed based on three sectors, these are: transport infrastructure, given by paved road network, total road network and railway lines; energy, proxied by total electricity generated in the economy; and lastly communication infrastructure, which is represented by the mobile phone subscriptions and number of main telephone lines in a country. Even though main telephone lines use has been on the decline by individuals particularly in LDCs, its usage in public and other private institutions is still important and therefore, worth considering.

2.5.5.5 Non-Stationarity of Variables

When linking infrastructure and economic growth, it is essential to solve the non-stationarity issue of some variables especially the infrastructure capital and aggregate output, which usually exhibit stochastic trends (Calderon et al., 2011). This study adopts a panel cointegration technique to address the issue of non-stationarity of the variables in the model and therefore, the issue of spurious regression is avoided since the variables are not regressed in their level form in a non-cointegration framework.

2.5.5.6 Panel Unit Root Tests

Dealing with panel time-series data, especially on growth and infrastructure requires a way to investigate and deal with non-stationarity. Panel unit root test helps to understand the properties of the variables in terms of stationarity. All variables should be integrated of the same order before conducting any cointegration tests, hence the need for unit root tests. Different panel unit root tests exist; however, this study used some recent tests in the literature of panel time-series, namely: Levin et al. (2002) known as Levin-Lin-Chu (LLC), another by Im et al. (2003) known as Im-Pesaran-Shin (IPS) test and lastly Fisher-type test by Maddala and Wu (1999) and Choi (2001) which involves ADF and Phillips Perron (PP) tests.

2.5.5.6.1 Levin-Lin-Chu Test

Levin, Lin, and Chu (2002) test has a null hypothesis that a panel has a unit root. It is modeled as:

$$\Delta y_{it} = \delta y_{it-1} + \sum_{L=1}^{p_i} \theta_{iL}\, \Delta y_{it-L} + \propto_{mi} d_{mt} + \varepsilon_{it} \qquad m = 1, 2, 3 \qquad (2.16)$$

The null hypothesis of $H_0\colon \delta = 0$, for all i, against the alternative hypothesis $H_1\colon \delta < 0$ for all i. The lag order p_i varies across individuals. It is selected by two methods of lag order selection in the ADF regressions, Information Criterion and lag selection through Sequential Testing. The selected lag orders are denoted as $\hat{p}_i$. The test is implemented as:

The ADF involves estimation of the following model:

$$\Delta y_{it} = \delta y_{it-1} + \sum_{L=1}^{\hat{p}_i} \theta_{iL}\, \Delta y_{it-L} + \propto_{mi} d_{mt} + \varepsilon_{it} \qquad m = 1, 2, 3 \qquad (2.17)$$

Where $\hat{p}_i$- is the selected lag orders.

Two orthogonalized residuals are generated by two regressions given as:

$$\Delta y_{it} = \sum_{L=1}^{\hat{p}_i} \theta_{iL}\, \Delta y_{it-L} + \propto_{mi} d_{mt} + e_{it}$$

$$y_{it-1} = \sum_{L=1}^{\hat{p}_i} \theta_{iL}\, \Delta y_{it-L} + \propto_{mi} d_{mt} + v_{it-1} \tag{2.18}$$

The residuals are saved as $\hat{e}_{it}$and $\hat{v}_{it-1}$, respectively. To eliminate heteroscedasticity, the residuals $\hat{e}_{it}$ and $\hat{v}_{it-1}$ are normalized by the regression standard error from the ADF regression.

2.5.5.6.2 Im-Pesaran-Shin

IPS test by Im, et al. (2003) takes into account the dynamics in the short-run heterogeneous short-run dynamics for various cross-sectional units. It involves taking the averages of the specific unit root test statistics. It is derived from the following equation:

$$\Delta y_{i,t} = \theta_i y_{i,t-1} + \sum_{j=1}^{\theta} \varphi_{ij} \Delta\, y_{i,t-j} + \delta_i + \varepsilon_{i,j};\ \ i = 1,2,\dots,N; t = 1,2,\dots,T \tag{2.19}$$

Where

$y_{i,t} -$ is each variable being considered in a model

δ_i $-$is individual fixed effect

ρ $-$is selected to ensure residuals are not correlated over time.

It is based on the null hypothesis that $\theta_i = 0, \forall i$, against an alternative hypothesis that $\theta_i < 0$ for some $i = 1,2,\dots,N_1$

The null hypothesis H_0: $\theta_i = 1$, implies the variable is non-stationary, $\forall i$.

The alternative hypothesis H_1: $\theta_i < 1$ for some i.

IPS test is based on the averages of the individual ADF statistics given by $\bar{t}$, which is written as:

$$\bar{t} = \frac{1}{N}\sum_{i=1}^{N} t\,(\theta_i)$$

Where $t\ (\theta_i)$ is the individual ADF *t*-statistic for country *i* based on ADF regression of each country in Equation (2.19). The ADF statistic $\bar{t}$ is assumed to follow a normal distribution and the critical values IPS test are provided by Im et al. (2003), given the values of *N* and *T*.

2.5.5.6.3 Fisher-Type Tests

This test was first proposed by Fisher (1932). For the case of panel unit root test, individual unit root tests are conducted on each separate panel series, after which a combination of *p*-values is used to get the overall test which then confirms the presence of a unit root in a panel series. Choi (2001) proposed four methods which combines *p*-values from panel individual unit-root test. The difference in the first three methods differ on the choice of transformation of the *p*-values using inverse χ^2, inverse-logit or inverse-normal transformation. The fourth method is appropriate when *N* approaches infinity and involves modifying the inverse χ^2as since the inverse-normal and inverse-logit are suitable when *N* is finite or infinite.

Maddala and Wu (1999) and Choi (2001) version of Fisher-test takes the form:

$$P = -2\sum_{i=1}^{N} ln\, p_i$$

Where p_i is asymptotic *p*-value of a unit root test for country *i*.

Fisher–type of tests can conduct either ADF or PP unit root tests on an individual panel depending on the specification made on which to apply.

2.5.5. 6.4 Breitung's Tests

Breitung (2000) test indicates that bias-corrected statistics for example LLC's bias-adjusted *t*-statistic (t_δ^*) suffers from low power, in particular. This results from the bias correction that eliminates the mean under the sequence of local alternatives (Baltagi, 2005). On the other hand, Breitung (2000) test statistic displays more power in such situations. Further, the test has good power even when small datasets are used, for example when $N = 25, T = 25$. However, the power of Breitung's test seems to decline under a fixed *T* and *N* is increasing.

2.5.5.6.5 Overview of Panel Unit Root Tests

IPS test is known to allow only limited restrictions and therefore, more powerful than LLC test which limits heterogeneity in the autoregressive coefficient. This problem of serial correlation in LLC is however solved by IPS which assumes heterogeneity between units in a dynamic model (Bangake and Eggoh, 2012). However, IPS test has a weakness as it assumes no CD which might result from unobserved common factors and residual interdependence which is not accounted for. By applying Monte Carlo experiments, Breitung came up with a test which does not undergo bias adjustment but has more power than that of LLC and IPS tests.

2.5.6 Test for Panel Cointegration

The test for cointegration is necessary when dealing with panel-time series data. PMG estimator by Pesaran, Shin and Smith (1999) can be used to estimate the relationship between infrastructure and real GDP if there is a cointegrating relationship.

If non-stationarity is detected in the variables, the next procedure is to test for cointegration in the econometric model. In econometric literature, some of the recommended tests include Kao (1999) and Pedroni (2004). It is worth noting that Pedroni's (2004) test for cointegration in panel data, like IPS test, takes into account heterogeneity by employing specific parameters which varies across countries (cross-sectional units). It is important to control for such heterogeneity since an assumption of identical vectors of cointegration among the cross-sectional units in the panel is unrealistic. If there is cointegration in the model, real GDP, infrastructure index, labour and physical capital, then the single cointegrating vector is interpreted as a long-run production function.

Before conducting cointegration test by Pedroni, it is required that the long-run relationship be first estimated, this is given by:

$$\ln Y_{i,t} = \alpha \ln INFR_{i,t} + \beta \ln X_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \qquad (2.20)$$

Where

$Y_{i,t}$ −is the real GDP per capita

$INFR_{i,t}$ −is the infrastructure variable

$X_{i,t}$ −is labour and physical capital

$\mu_i -$ fixed effects

$\delta_t -$time specific effects

$\varepsilon_{i,t} -$is the error term.

The estimated residuals take the form:

$$\hat{\varepsilon}_{it} = \hat{\theta}_i \hat{\varepsilon}_{it-1} + \hat{\epsilon}_{it}$$

Where $\hat{\theta}_i$, is the first-order auto-correlation coefficient. This implies that the estimated residuals are assumed to take the 1st order serial correlation. The residuals, therefore, follow first-order autoregressive process.

Pedroni's panel test has seven different types of statistics categorized into two broad groups: Within dimension which comprises four different statistics and involves pooling, and Between dimension which comprises of the remaining three. Nevertheless, the two types of tests have a similar null hypothesis, indicating cointegration. The tests, however, have different forms of alternative hypothesis, that is, the within dimension tests assume an alternative hypothesis of: $\theta_i = \theta < 1, \forall i$, while the between dimension tests have the alternative hypothesis of: $\theta_i < 1, \forall i$ (Bangake and Eggoh, 2012).

2.5.7 Pooled Mean Group Estimator

PMG estimator attributed to Pesaran et al. (1999) is consistent if long-run slope homogeneity assumption is held. PMG encompasses both pooling and averaging and allows short-run coefficients and error variances to vary by country. However, long-run estimates are controlled to be identical. Implying that, the PMG estimator allows the short-run dynamics to have unrestricted cross-sectional heterogeneity but imposes homogeneity on the long-run estimates.

When the time period is long, PMG estimator, which allows the short-term parameters to be independent but imposes similarity of the long-run parameters, is known to perform better than other panel data estimators for example GMM, random and fixed effects models. This is because the other panel data estimators or models restrict the parameters to be identical across the cross-sectional units, a condition which might result in long-run coefficients which are misleading and inconsistent.

PMG estimator is used to estimate equation (2.10). Transforming equation (2.10) into an ARDL (p, q) model, we get the following equations:

The unrestricted ARDL model is specified as:

$$y_{it} = \sum_{h=1}^{p} \alpha_{i,h}\, y_{i,\mathrm{t}-h} + \sum_{h=0}^{q} \lambda'_{i,h}\, \Delta X_{i,\mathrm{t}-h} + \delta_i + \varepsilon_{it} \qquad (2.21)$$

Where

y_{it} − is real GDP

$X_{i,\mathrm{t}}$ − is a $k \times 1$ vector of regressors

$\alpha_{i,h}$ − are scalar coefficients of the lagged real GDP

$\lambda'_{i,h}$ − are $k \times 1$ coefficient vectors

δ_i − is individual specific fixed effect

By re-writing equation (2.21) into an ECM, the following equation is obtained:

$$\Delta y_i = \varphi_i\big(y_{i,-1} - X_{i,-1}\beta\big) + \sum_{h=1}^{p-1} \alpha_{i,h}\, \Delta y_{i,-h} + \sum_{h=0}^{q-1} \lambda'_{i,h}\, \Delta X_{i,-h} + \delta_i t + \varepsilon_i \qquad (2.22)$$

Where

i refers to cross-sectional units, $i = 1,2, \dots, N$

$\varphi_i = -(1 - \sum_{h=1}^{p} \alpha_{i,h}),\ \alpha_{i,h} = -\sum_{m=h+1}^{p} \alpha_{i,m}$, $h = 1,2, \dots, p - 1$, and

$\lambda_{ih} = -\sum_{m=h+1}^{p} \lambda_{im}, j = 1,2, \dots, q - 1$.

$\beta_i = \beta\ \forall i$ is homogeneity restriction of the long-run parameters

$y_i = (y_{i1}, \dots, y_{iT})'$ is the$T \times 1$vector containing T observations of real GDP for country *i* in the panel.

X_i −is the $T \times 3$ matrix of variables, namely infrastructure (INFR), labour (L) and physical capital (K)

$\boldsymbol{\varphi_i}$ −are coefficients which captures the speed of adjustment towards the long-run equilibrium.

$\boldsymbol{\iota}$ –is a vector of ones of dimension $T \times 1$

δ_i – is individual specific fixed effect

$\mathcal{E}_i = (\varepsilon_{i1}, \dots, \varepsilon_{iT})'$are the error terms which are uncorrelated across countries (*i*) and time (*t*).

From Equation (2.22), the short-run coefficients and adjustments speed varies across countries in a PMG estimator while the long-run coefficients are constrained as identical over a cross-section. This results in heterogeneous short-run dynamics and pooled long-run coefficients. The implication of this is an outcome which lies between full parameter homogeneity and unrestricted heterogeneity. Therefore, according to the PMG estimator, the short-run link between growth and infrastructure development is expected to differ from one Partner State to another; while, the long-run relationship is expected to be identical among the countries.

In Equation (2.22), the error correction coefficient captures the speed with which variables in the model diverge or converge to equilibrium. It should be negatively signed, and statistically significant. If the value is zero, then it signifies no evidence for a long-run relationship.

Based on concentrated log-likelihood function, the long-run coefficients of Equation (2.21) are obtained under normality assumption (Calderon et al., 2011). From an iterative non-linear process, long-run parameters are obtained after running individual OLS regressions of Δy_i on $y_{i,-1} - X_{i-1}\beta$.

Since the error terms were assumed to be independently distributed across countries (*i*) and time (*t*), implying that they are uncorrelated across (*i*) and (*t*). Further, it was also assumed that $\varphi_i < 0, \forall i$. Therefore, the existing long-run relationship in the model is given as:

$$y_{it} = \sigma' X_{it} + \gamma_{it} \quad i = 1,2, \dots, N; \quad t = 1,2, \dots, T$$

Where

$\sigma_i = -\beta_i/\sigma_i$, is a $k \times 1$ vector of the long-run coefficients, which are non-stationary and likely to have non-zero means. By rewriting Equation (2.22), the following equation is obtained:

$$\Delta y_{it} = \varphi_i \gamma_{i,t-1} + \sum_{h=1}^{p-1} \alpha_{i,h} \Delta y_{i,-h} + \sum_{h=0}^{q-1} \lambda'_{i,h} \Delta X_{i,-h} + \delta_i + \varepsilon_{it} \qquad (2.23)$$

From Equation (2.23), the term $\gamma_{i,t-1}$is the error correction term and φ_i is the error correction term coefficient. It should be negatively signed and statistically significant. The assumption under PMG estimation which allows for differences in short-run coefficients by countries but constrains the long-run coefficients to be equal implies that $\sigma_i = \sigma, \forall i$.

Pooled maximum likelihood estimation technique was applied by Pesaran et al. (1999) to estimate the short-run coefficients and the similar long-run coefficients. Under the assumption of normal distribution of the error terms, the PMG estimators are given as:

$\hat{\varphi}_{PMG} = \frac{\sum_{i=1}^{N} \tilde{\varphi}_i}{N}$, $\hat{\beta}_{PMG} = \frac{\sum_{i=1}^{N} \tilde{\beta}_i}{N}$, $\hat{\alpha}_{hPMG} = \frac{\sum_{i=1}^{N} \tilde{\alpha}_{ih}}{N}$, $h = 1,2, \dots, p-1$ and

$\hat{\lambda}_{hPMG} = \frac{\sum_{i=1}^{N} \tilde{\lambda}_{ih}}{N}$,$h = 0,1,2, \dots, q-1$,$\hat{\sigma}_{PMG} = \tilde{\sigma}$

The final PMG equation estimated is given as:

$$\Delta lny_{it} = -\varphi_i\left(lny_{i,t-1} - \sigma_1 lnK_{i,t} - \sigma_2 lnL_{i,t} - \sigma_3 lnINFR_{i,t} - \alpha_{m+1}t - \sigma_{0,i}\right) + \beta_{1,i}\Delta lnK_{i,t} + \beta_{2,i}\Delta lnL_{i,t} + \beta_{3,i}\Delta lnINFR_{i,t} + \varepsilon_{i,t} \quad (2.24)$$

Where Δ implies first difference

PMG estimator requires optimal lag length for the specific country equations. In this respect, Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC) are employed in this study.

2.5.8 Granger Causality Test

The existence of cointegration suggests that there is either a uni- or a bi-directional causality between two such variables (Engle and Granger, 1987). Granger causality test is applied to identify if one variable affects the other (Granger, 1969). The test is based on the assumption that a variable *X* Granger causes *Y* if *Y* can be predicted using past data of both *X* and *Y* than relying on the history of *Y* alone. The test is modeled as:

$$y_t = \beta_0 + \sum_{i=1}^{m} \beta_i\, y_{t-i} + \sum_{i=1}^{m} \delta_i\, x_{t-i} + \varepsilon_t \quad (2.25)$$

$$x_t = \beta_0 + \sum_{j=1}^{m} \beta_j\, y_{t-j} + \sum_{j=1}^{m} \delta_j\, x_{t-j} + \varepsilon_t \quad (2.26)$$

The test is based on the null hypothesis: X does not Granger-cause Y, the rejection of the null hypothesis implies X Granger-causes Y. On the other hand, the null hypothesis is that Y does not Granger-cause X . These can be given as:

$$H_0: \delta_i = 0, \qquad i = 1, 2, \dots, m \tag{2.27}$$

$$H_0: \delta_j = 0, \qquad j = 1, 2, \dots, m \tag{2.28}$$

Since cointegration relationship was confirmed in the model, this study conducted granger causality test to establish the nature of causality between economic growth and infrastructure stock.

2.6 Results and Discussion

2.6.1 Introduction

This section discusses the results of the analysis. More specifically, it discusses statistical properties of variables, presents results of unit root tests carried out to establish stationarity and cointegration of the variables. In addition, it presents and discusses the regression results of the study.

2.6.2 Descriptive Statistics

It is important to describe data to understand the properties of the variables in a model. Hence, all the variables used in the study were investigated in terms of the mean, standard deviation, skewness, kurtosis and the range (Table 2.3).

EAC had an average real GDP per capita (RGDPP) of United States Dollar (US$) 605.9 over the period 1990-2019, with a minimum of US$ 208.07 and a maximum of US$ 1,237.50, implying a widespread in RGDPP among the EAC Partner States. The physical capital stock as constructed using PIM, averaged US$ 25.4 billion, while the average number of workers as given by the labour force data in EAC during the 1990-2019 was about 10.3 million. The average number kilometers of paved roads in the region was 4,614.14, while the average total road network comprising of both paved and unpaved roads was 35,180.41 kilometers. However, the railway network in the region had a lower average of 1,320.46 kilometers. This small number is because both Rwanda and Burundi do not have any established railway system. This explains the minimum value of 0 kilometers because of non-existent railway network in Rwanda and Burundi, and a maximum value of 3,926 kilometers.

In terms of energy production, the average total electricity production capacity in the region over the 30-year period was 2,498.41 GWh. Kenya is the leading country in terms of electricity production because of diversified means of electricity generation other than hydro such as geothermal and wind. Rwanda and Burundi have lower electricity generation capacity respectively due to heavy reliance on hydro. With regards to communication, the region recorded an average of 231 fixed lines and mobile phone subscribers per 1000 inhabitants, this number is relatively low, implying slow pace of uptake of technology in the region.

Table 2.3: Descriptive Statistics of Variables

Variable	Mean	Std. Dev	Skewness	Kurtosis	Min.	Max.	Unit
RGDPP	605.95	270.17	0.12	1.91	208.07	1,237.50	2010 US$
Capital	25.4	31.4	1.71	5.71	0.16	154	2010 US$ (Billion)
Labour	10.30	6.72	0.62	2.29	2.57	27.20	No. of Labourers (Million)
Paved Roads	4,614.14	5,478.19	1.47	5.27	780	21,295.11	Kilometers
Total Road Network	35,180.41	39,745.90	1.52	4.97	3510	164,091.60	Kilometers
Railway Line	1,320.46	1,242.21	0.27	1.70	0.00	3,926	Kilometers
ELEC	2,498.41	2,720.76	1.24	3.97	92	9,971	Gigawatts
MTEL	4.68	3.04	1.52	5.54	1.00	17	No. of Main Lines
FMTEL	231.13	289.79	0.91	2.24	1.00	860	No. of Phone Lines
MBTEL	23.25	29.34	0.88	2.26	0	97.14	No. of Mobile phones

***Note:** RGDPP-Real GDP per capita, INFR-Infrastructure, ELEC-Electricity, MTEL-Number of main lines per 1000 inhabitants, FMTEL-Fixed and mobile phone subscriptions/1000 inhabitants MBTEL-Mobile phone subscriptions per 100 inhabitants and K-Physical Capital. The descriptive statistics were based on 150 observations from 5 countries in EAC, from 1990-2019.*

With respect to skewness, all the variables have a positive skew, implying that all distributions have long right tails. Therefore, most of the variables have many small values and few large values during later periods of the study. This means that most of the variables experienced very low growth rates during the initial period under consideration. In terms of kurtosis, capital stock, paved roads and number of main lines per 1000 inhabitants has a kurtosis which is greater than 3, implying a Leptokurtic distribution. The rest of the variables have a kurtosis of less than 3, a Platykurtic distribution.

2.6.3 Principal Component Analysis

The first index for infrastructure stock, $IS1$, is composed of information on paved road network in kilometers, electricity generating capacity in gigawatts, and main telephone lines per 1,000 inhabitants for the 5 EAC Partner States covering the period 1990-2019. The other index, for robustness checks is given by $IS2$, it uses total road network in kilometers (paved and unpaved) and total railway network in kilometers, electricity generation capacity, and mobile phone and telephone subscriptions per 1000 inhabitants. All infrastructure variables are transformed into logs before the indexes are constructed in order to attain normality.

The correlation between the variables used in first infrastructure stock index $IS1$ is such that, paved roads and electricity generation have the highest correlation of 0.96, while the correlation between paved roads and main telephone lines is 0.69. The correlation between electricity generation and main telephone lines is 0.63. The high correlation between the infrastructure variables implies that they can be summarized in one infrastructure index and minimizes the possibility of any multicollinearity. Multicollinearity is avoided because the different infrastructure variables which are correlated are not included as independent variables in one regression model instead, they are combined to form one variable which is used in a regression model.

2.6.3.1 Eigenvalues and Eigenvectors

Eigenvalues show the order of importance of the different principal components. Eigenvalues of above 1 are always preferred. Table 2.4 gives the results.

Table 2.4: Eigenvalues for First Index for Infrastructure Stock

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.3686	1.7695	0.7895	0.7895
Comp2	0.5991	0.5667	0.1997	0.9892
Comp3	0.0324	-	0.0108	1.0000

The first principal component has the largest eigenvalue of 2.37 and explains 79 percent of the total variance. The second and third principal components have eigenvalues of 0.60 and 0.03 and explain 20 percent and 1 percent of the total variance respectively. The correlation of the first principal component with the individual variables is, 0.61 with paved road network, its correlation with electricity generating capacity and phone subscriptions is 0.63 and 0.48 respectively. Further, weights of the three variables in the first principal component are given by the various values of the eigenvectors as shown in Table 2.5.

Table 2.5: Eigenvectors for First Index for Infrastructure Stock

Variable (in Logs)	Comp1	Comp2	Comp3
Paved Roads	0.6099	-0.4172	0.6738
Electricity	0.6308	-0.2591	-7314
Telephones	0.4797	0.8711	0.1052

The eigenvectors represent the weight (loadings) that each infrastructure variable enters each principal component. The first principal component shows that all the infrastructure variables are represented, as they all enter with positive weights and therefore, used to construct the first infrastructure index as shown in Equation (2.6.1). A positive loading signifies that a variable and a principal component are positively correlated. On the other hand, a negative loading implies a negative correlation. For example, paved roads and electricity generating capacity have negative weights with the second principal component, implying that they have a negative correlation. The third component has a mixture of positive and negative weights, implying positive correlation with paved roads and main telephone lines and a negative correlation with electricity generating capacity. Therefore, the first principal component is chosen to construct the index for infrastructure quantity.

$$IS1_{it} = 0.61lnPR + 0.64lnELEC + 0.48lnMTEL \quad (2.6.1)$$

Where

$IS1_{it} -$ is the first index for infrastructure stock

$lnPR -$ is paved road network (in logs)

$lnELEC -$is electricity generating capacity (in logs)

$lnMTEL$ −is main telephone lines/1,000 workers (in logs)

From Equation (2.6.1) it is evident that both paved road network and electricity generating capacity enter the first principal component with weights of 0.61 and 0.63 respectively, which are almost equal. On the other hand, main line and mobile phone subscriptions per 1,000 inhabitants enter the first principal with a weight of 0.48, slightly lower than the other two.

This study, for robustness checks went ahead and constructed another index $IS2$, which used a more comprehensive measure of transport infrastructure. The study combined total road network comprising of both paved and unpaved roads in kilometers together with the railway network in a country, electricity generating capacity and main telephone lines and mobile phone subscriptions per 1000 inhabitants. The results are given in Table 2.6.

Table 2.6: Eigenvalues for Second Index for Infrastructure Stock

Component	**Eigenvalue**	**Difference**	**Proportion**	**Cumulative**
Comp1	2.9278	2.0113	0.7319	0.7319
Comp2	0.9165	0.7821	0.2291	0.9611
Comp3	0.1344	-	0.0389	1.0000

Principal component 1 has an eigenvalue of 2.93 and explains 73 percent of the variations, it is therefore chosen in this case. On the other hand, correlation between transport infrastructure network as measured by total road and railway network and electricity generation is 0.90, which is still high, however the correlation between transport infrastructure and communication infrastructure is 0.33, while the correlation between electricity generation and communication infrastructure is 0.42.[11] The low correlation between transport and communication infrastructure is because modern communication technology such as mobile telephony does not necessarily rely on transport infrastructure to operate. Additionally, the low correlation between installed capacity of electricity and communication infrastructure is because of the increasing importance of other sources of energy such as solar power, which are off the main grid. The eigenvectors are given in Table 2.7.

[11]These values are obtained from pairwise tests conducted before constructing an index using PCA.

Table 2.7: Eigenvectors for Second Index for Infrastructure Stock

Variable (in Logs)	Comp1	Comp2	Comp3
Road & Rail	0.5531	-0.1240	-0.8178
Electricity	0.5773	0.0022	0.2980
Phones	0.4162	0.9426	0.0528

The resulting infrastructure index $IS2$, is given as:

$$IS2_{it} = 0.55lnRR + 0.58lnELEC + 0.42lnMPTEL \qquad (2.6.2)$$

Where

$IS2$ −is the second index for infrastructure stock

$lnRR$ −is the total road and railway network in kilometers (in logs)

$lnMPTEL$ −is main telephone lines and mobile phone subscriptions/ 1000 workers (in logs)

From Equation (2.6.2), both total road and railway network and electricity generation enter the first principal component with weights of 0.55 and 0.58 respectively, while phone subscriptions per 1000 workers enter the component with a weight of 0.42. This implies that the infrastructure variables in the second index $IS2$ have entered with approximately similar weights as that of the first index $IS1$. Further, all the weights are positive, an indication that all the sample infrastructure variables are represented in the index.

After computing the two infrastructure indices, the mean and median of infrastructure index for individual country were computed and the findings presented in Figure B1 (in Appendix B). From the first infrastructure index results, Kenya is well-endowed in terms of infrastructure as compared to her EAC counterparts. Kenya has an average and median infrastructure stock of 1.52 and 1.16 respectively, followed by Tanzania which has average and median infrastructure stock 0.44 and 0.10 respectively. Uganda comes third with average and median infrastructure stock of -0.38 and -0.47; Burundi has an average and median infrastructure stock of -0.77 and -0.77 respectively and finally, Rwanda comes last with average and median infrastructure stock of -0.81 and -0.82 respectively. The results show that both the average and median values represent similar information in terms of stock.

From the second infrastructure index, the average and median infrastructure stock for each country was computed (see Figure B2 in Appendix B). From the results, Kenya and Tanzania have the largest infrastructure stock in comparison to the rest of the EAC Partner States, with both having an average of stock of 0.88. This is because this index considered the total road (paved and unpaved) and railway network, electricity generating capacity and main telephone and mobile phone subscribers per 1000 workers. Tanzania has both lengthy unpaved roads and railway network like Kenya. Uganda comes third with average infrastructure stock of 0.6, Burundi and have an average of -1.22. Burundi and Rwanda perform poorly because they do not have any existent railway network.

2.6.4 Correlation Results

The absolute value of the correlation coefficient ranges from 0 to 1. A negative correlation coefficient is an indication of an opposite relationship between the variables and a positive one for direct relationship. Log transformation of the variables was done to attain normality and then correlations were computed, the results are shown in Table 2.8.

Table 2.8: Correlation Matrix of Variables in Levels

	LRGDP	LK	LL	INFR
LRGDP	1			
LK	0.8265***	1		
LL	0.8182***	0.9365***	1	
INFR	0.7151***	0.6916***	0.7690***	1

***Note:** LRGDP-Log of Real GDP per capita, LK-Log of Capital, LL-Log of Labour and INFR-Infrastructure. *** implies statistically significant at the 0.01 level (2-tailed)*

The correlation between RGDP and capital stock is positive. This is because capital accumulation is crucial for economic growth. Therefore, countries with high stock of capital are linked with higher productivity levels and higher growth rates. This implies that, factor accumulation is key for growth. The relationship between RGDP and amount of labour also positive, and this can be very strong with skilled labour force. This is because abundant labour supply lowers the cost of production hence higher output. EAC Partner States have relatively high levels of labour supply which should be a key driver of growth. RGDP and infrastructure stock are also positively correlated in EAC. Infrastructure development comes with many benefits as it complements other factors of production, thereby promoting growth.

2.6.5 Econometric Tests

2.6.5.1 Cross-Sectional Dependence Test

Before conducting any panel data empirical analysis, it is essential to conduct a test for CD. The study employed Pesaran CD test which tests whether the residuals are correlated across countries. The results are presented in Table 2.9.

Table 2.9: Pesaran Test for Cross-Sectional Dependence

	Pesaran's Test of Cross-Sectional Independence	*P*-Value
Pesaran CD test	0.327	0.7435
Average absolute value of the off-diagonal elements	0.54	

The results shown in Table 2.9 imply that there is of no CD at 5 percent level of significance. Therefore, panel unit-root tests such as used IPS, LLC and Fisher can be applicable to examine properties of the variables in terms of stationarity.

2.6.5.2 Panel Unit Root Tests

Running a regression with a non-stationary level data is likely to produce spurious regression and inconsistent results and therefore conclusions based on such data do not make sense. The variables in the study namely economic growth, physical capital stock, labour and infrastructure index were subjected to unit root tests to establish their stationarity. The study used IPS, LLC, Fisher and Breitung tests for panel unit roots to ensure that the results are robust.

The test for panel unit roots is presented in Table 2.10.

Table 2.10: Tests for Panel Unit Roots

Methods		LLC	IPS	Fisher-ADF	Breitung
Variable		**Statistic**	**Statistic**	**Statistic**	**Statistic**
Level	LRGDPC	-0.17	4.62	4.61	5.31
	LK	1.04	-6.63***	-17.4***	6.36
	LL	2.55	9.60	1.24	9.62
	INFR	3.99	8.19	0.09	5.29
First Difference	ΔLRGDP	-3.03***	-3.77***	-6.38***	-3.28***
	ΔLK	-4.75***	-8.42***	-36.21***	-1.41**
	ΔLL	-10.18***	-1.25**	-1.49**	-1.59**
	ΔINFR	-4.12***	-5.06***	-10.63***	-5.75***

**** and ** imply statistical significance at 1 and 5 percent respectively, $\Delta -$denotes first difference. All the variables are as earlier defined.*

The results in Table 2.10 show the panel unit root test of LLC, IPS and Fisher that were applied to each of the variables in the model. The variables RGDP, LL and INFR were confirmed as non-stationary in level form by all the tests. However, the variable LK was found to be non-stationary by LLC and Breitung test and found to be stationary by IPS and Fisher tests. The variables were then differenced after which they became stationary, therefore, then null hypothesis of non-stationarity was rejected. A conclusion from the results implies that the variables are integrated of order one, I (1).

2.6.5.3 Panel Cointegration Tests

After unit roots tests, the next procedure was to test for cointegration. Westerlund (2005), Pedroni (2004) and Johansen Fisher tests for panel cointegration were used. The results are presented in Table 2.11.

All the cointegration tests imply that the null hypothesis is not accepted. In Table 2.11, the null of no cointegration is rejected by four out seven of Pedroni's tests. This test is generally known to be robust to any form of causality that may exist in the model. In Table C1 and C2 (in Appendix C) both the Westerlund's and Johansen Fisher test results also reject the null hypothesis of no cointegration at 5 and 1 percent level of significance respectively, implying that economic growth and the regressors in the model are cointegrated for the EAC Partner States. The presence of long-run relationship between economic growth and the other variables in the model makes economic sense since infrastructure development is likely to significantly influence growth in the long-run. The next step after confirmation of a long-run relationship is estimation of the growth model using a PMG estimator.

Table 2.11: Pedroni Cointegration Test Results

Test Statistic	Statistic	P-Value
Within Group		
V-Statistic	0.496	1.043
Rho- Statistic	1.235	1.42
PP- Statistic	-4.770***	0.000
ADF- Statistic	-2.031***	0.000
Between Group		
Group rho-Statistic	0.942	0.764
Group pp-Statistic	-1.862**	0.021
Group ADF-Statistic	-1.814**	0.027

*Note: *** and ** Indicate that parameter is statistically significant at 1percent and 5percent respectively*

2.6.6 Results of Regression Analysis

The analysis of infrastructure stock and economic growth was based on panel time series data estimator, PMG. This gives a chance to control for any endogeneity that may arise, omitted variables and ability to explore data across time. It is also important before the regression, to eliminate the effects of CD. Pesaran CD test was carried out (see Table 2.9) and it revealed that the variables are cross-sectionally independent and therefore, regression was carried out without the problem of CD.

To determine the choice between MG and PMG estimators, Hausman test was carried out under the null hypothesis that PMG is preferred in regression against an alternative of MG being preferred. Hausman test was conducted[12] and the value was 3.58 with a p-value of 0.6117, implying the null hypothesis is accepted and therefore the PMG estimator was preferred for regression. This was also an indication that the long-run homogeneity assumption held.

In this study, Akaike Information Criterion (AIC) was used to determine the order of ARDL specification. The ARDL model (2, 2, 2, 2), implies all the variables in the model were tested

[12] see Table D1 in Appendix D

such that infrastructure and other variables were tested to the highest lag of 2. The long-run PMG results are presented in Table 2.12.

Table 2.12: PMG Estimation Results

Dependent Variable: Log of Real GDP Per Capita				
Variable	Coefficient	Std. Error	t-Statistic	P-Value
LINFRA	0.1999***	0.0760	2.6313	0.0098
LK	0.2433**	0.1102	2.2087	0.0294
LLB	0.6014***	0.1687	3.5612	0.0006
No. of Countries	5			
No. of Obs.	140			
Log Likelihood	348.98			

*** and ** -Significance at 1 and 5 percent respectively

The empirical model was estimated using data on each of the chosen variables covering a 30-year period for all the 5 EAC Partner States. The long-run estimates of the PMG model in Table 2.12 show that a 1 percent increase in infrastructure stock increases economic growth by 0.20 percent. This conforms to endogenous growth framework in a model with constant returns to aggregate capital where accumulation of infrastructure stock has a positive impact on real GDP per capita, particularly if infrastructure is below an efficient level in a country (Canning and Pedroni, 1999). EAC Partner States still have relatively low levels of infrastructure stock (below the efficient level), and therefore, any addition to the existing stock is likely to influence growth positively. In theory, infrastructure can affect growth directly as a factor input in a production process, hence any increase in infrastructure stock would stimulate economic growth by lowering the cost of production. For example, energy acts as an important input in production of different goods and services such that adequate and reliable power supply is likely to stimulate the growth process. Infrastructure can also promote economic growth by complementing factor inputs by lowering the cost of production and boosting the productivity of existing factors. The findings of this study support the findings by Romp and de Haan (2005), Calderon (2009), Sahoo et al. (2010), Straub and Terada-Hagiwara (2011), German-Soto and Bustillos (2014) and Badalyan et al. (2014. However, the findings contrast those of Kustepeli et al. (2012), Crescenzi and Rodriguez-Pose (2012), Kodongo and Ojah (2016) and Ansar et al. (2016) who are of the view that infrastructure has very little contribution to economic growth.

Both physical capital stock and the labour force have a positive long-term relationship with growth. A 1 percent increase in physical capital increases GDP per capita by 0.24 percent in EAC. However, an increase in productive labour force by 1 percent results in an increase in economic growth by around 0.60 percent. These results can also be interpreted in terms of elasticities such that output elasticity of capital and labour for the EAC Partner States are 0.24 and 0.60 respectively. From the theoretical model adopted in this study, economic growth is a function of both physical capital and labour, in addition to infrastructure. Theoretically, accumulation of physical capital for instance, is associated with economic growth since more factors of production become available and are utilized in production process.

Table 2.13 presents the short-run PMG estimation results.

Table 2.13: Error Correction Model PMG Estimation Results

Dependent Variable: Log of Real GDP Per Capita

Variable	Coefficient	Std. Error	t-Statistic	P-Value
ECT_{t-1}	-0.4206**	0.1301	-3.2329	0.0225
dINFRA$_{t-2}$	0.3365	0.4019	0.8372	0.4044
dLK_{t-2}	0.5108	0.5259	0.9713	0.3337
dLL_{t-2}	0.2966**	0.1280	2.3167	0.0235
Constant	0.7719	0.7257	1.0637	0.2900

Note: ECT-Error correction term and dX_i-Implies that variable has been differenced.

The short-run PMG estimates are presented in Table 2.13. The coefficient of error correction term is correctly signed, negative and statistically significant at 1 percent level of significance. This means that the model is statistically significant and that up to 42.1 percent of the disequilibrium in the model is corrected within a year which ensures that the long-run relationship is kept intact. The effect of infrastructure stock on growth in the short-run is not statistically significant. This is expected because infrastructure development is most likely to promote growth in the long-run. Similarly, physical capital stock has positive but not statistically significant effect on per capita real GDP in the short-run. This is because, in the short-run, capital stock is unlikely to change because it takes time to install capital stock. An increase in the labour force by 1 percent leads to an increase in real GDP per capita by 0.30

percent.[13] This means that the effect of labour force is superior in the long-run than in the short-run, implying that workers are likely to acquire more skills with time as a result of education and other forms of training. Further, EAC Partner States are not heavily industrialized and therefore most of the production systems are labour intensive. This means that labour force forms an important component of production process such that output increases with more employment of workers.

The study, for robustness checks, regressed paved roads (PR), electricity generating capacity (ELEC), fixed telephone subscriptions (FTS) and mobile phone subscriptions (MPS) using panel fully modified ordinary least squares. The results are presented in Table 2.14.

Table 2.14: Effect of Selected Infrastructure Indicators on Real GDP

Dependent Variable: Log of Real GDP Per Capita

Variable	(1)	(2)	(3)	(4)
LK	0.2642***	0.1767***	0.2317***	0.2719***
LLB	0.5937**	0.5370**	1.0068***	0.4474
L(PR)	0.3092***			
L(ELEC)		0.3334***		
L(FTS)			0.1758***	
L(MPS)				0.0033**
No. of Countries	5	5	5	5
No. of Obs.	145	145	145	145
Adj. R^2	0.9324	0.9378	0.9808	0.9823

*Note: *** and ** -Significance at 1 and 5 percent respectively*

The findings imply that the elasticity of physical capital ranges from 0.18 to 0.27 for all the four regression models. The elasticity of labour ranges from 0.54 to 1.01 for the alternative regression models presented. For different infrastructure indicators, paved roads have an elasticity of 0.31, electricity generating capacity has an elasticity of 0.33, fixed telephone subscriptions have elasticity of 0.18 while mobile phone subscriptions have an elasticity of 0.003.

[13]As earlier explained, due to data limitations, labour force was not disaggregated into skilled and unskilled workers and establish their effects on output. This study therefore used the aggregate number of workers in the estimation.

2.6.7 Granger Causality Test

The test was based on the null hypothesis that infrastructure does not Granger- cause economic growth. The results are presented in Table 2.15.

Table 2.15: Granger Causality Test Results

Equation	Excluded	χ^2	df	P>χ^2
ΔLRGDPP				
	ΔINFRA	5.6095	4	0.046
	ALL	5.6095	4	0.046
ΔINFRA				
	ΔLRGDPP	2.558	4	0.759
	ALL	2.558	4	0.759

Note: ΔX_i*-Implies that variable has been differenced*

The results show that the direction of causality is uni-directional from infrastructure to growth, and not vice versa. Infrastructure, therefore, Granger causes economic growth in EAC in the long-term. This implies that, it is infrastructure development that leads to increase in RGDP per capita in EAC in the long-run and economic growth does not necessarily result in more demand for infrastructure. The study findings are similar to Chakamera and Alagidede (2017).

2.7 Summary, Conclusions and Policy Implications

2.7.1 Summary

The study empirically estimated a production function linking economic growth to infrastructure stock, labour and non-infrastructure capital as inputs. The analysis was based on the PMG estimator to address any heterogeneity issues that could arise. The results reveal the existence of a long-term equilibrium relationship between economic growth, infrastructure, capital and labour force, hence the choice for PMG estimator. Specifically, the results demonstrate that infrastructure development has a positive effect on growth of EAC Partner States during the 1990-2019 period. However, the results show that the impact of infrastructure stock on growth is evident in the long-term but not in the short-term. This is because the benefits of infrastructure development take time to be realized. For the EAC Partner States, this is realised after about 2 years with an output elasticity of infrastructure stock of 0.20.

Estimates from the augmented production function show that capital stock positively affects real GDP per capita in the long-term. It was estimated that output elasticity of capital stock was 0.24, clearly demonstrating the important role of capital accumulation in the growth process. The short-run effect of capital stock was positive but not statistically significant, implying that capital accumulation takes time and most of the capital investments have long gestation periods hence little effect on growth in the short-run.

The results also confirmed that labour force is among key factors to EAC's growth. There was a positive link between labour force and economic growth both in the short-and long-run. The output elasticity of labour was estimated at 0.60 in the long-run. This is because EAC Partner States are still developing and rely mainly on labour intensive techniques of production and therefore labour forms an important input in the production process.

A uni-directional causality exists between infrastructure stock and growth in EAC Partner States. This implies that accumulation of infrastructure explains growth in EAC but not vice versa. Theoretically, this is justifiable as infrastructure stock (transport, energy and communication infrastructure) are considered as basic inputs in the production process. Consequently, building more roads, construction of railway lines, increasing the installed capacity of electricity generation and more communication infrastructure are expected to promote economic growth in EAC. The results are in line with a previous study by Sahoo et al. (2010).

2.7.2 Conclusions

This study confirms a positive contribution of infrastructure stocks to economic growth using PMG estimation technique. However, in the short-run, infrastructure development does not significantly influence EAC's growth. Significant effect on growth is only experienced in the long-term. Therefore, from the findings of this study, a long-run relationship exists between infrastructure stock and economic growth in the EAC.

Development of infrastructure is important for economic growth in EAC. This implies that growth in EAC is likely to be propelled through increased infrastructure stock. This results from both direct and indirect benefits created in the economy. However, the stock of infrastructure in EAC is still low in comparison to other regional economic blocs in Africa hence more investments are needed to boost the infrastructure stock.

2.7.3 Policy Implications

The empirical findings from this study are very useful in demystifying the nexus between economic growth and infrastructure development. The main policy that may be inferred from this study is that, for sustained long-term growth, it is important for the EAC Partner States to pursue policies that aim at increasing the level of infrastructure stock. Since EAC countries are still pursuing policies that will accelerate their growth process, it is crucial to invest in the right form of infrastructure. This study has shown that transport, energy and communication infrastructures are very important in promoting economic growth in these countries, and therefore more priority should be given to their development. Consequently, for the EAC countries to increase economic growth, additional investment in infrastructure remains critical. This can be done by leveraging public-private partnerships as an alternative source of financing.

Energy is an important component of infrastructure. However, the structure of electricity generating capacities of EAC Partner States reveals that these countries rely mainly on hydro-electric power. This form of energy generation is negatively affected during drought which lowers the amount of electricity generated. Therefore, diversification of electricity production sources is necessary to increase electricity production and reliability.

ESSAY TWO

RELATIONSHIP BETWEEN PUBLIC INFRASTRUCTURE AND PRIVATE INVESTMENT

3.1 Introduction

This essay analyses the relationship between infrastructure and private investment in EAC. It aims at identifying whether public infrastructure development complements or crowds-out private investment in EAC. Sections 3.2, 3.3 and 3.4 respectively provide a theoretical, empirical and a summary of the reviewed literature on infrastructure and private investment. Section 3.5 discusses the methodology used in this study while section 3.6 presents and discusses the results. Section 3.7 summarises, concludes and gives policy implications.

Private investment is very important for sustained economic growth. However, there is lack of consensus with respect to how public investment affects private investment. Generally, public investment in infrastructure should encourage private investment. This suggests that, public investment can promote economic growth directly and also indirectly by encouraging private sector investment, also known as crowding-in (Erden and Holcombe, 2005). Conversely, another school of thought believe that public investment may crowd-out private investment, a situation which results in varied policy implications with respect to public investment. Thus, whether or not public investment promotes economic growth is determined by the dominant effect. This is a key policy issue which requires empirical investigation particularly in the EAC that has experienced increased public investment in infrastructure over the past two decades.

3.2 Theoretical Literature

Theoretical foundations on public infrastructure and private investment point to three different theories namely Keynesian, Neoclassical and Ricardian Equivalence. Keynesian theory assumes that an economy operates below full employment and that increases in public spending boosts economic activities hence crowding-in private investment (Keynes, 1936). Neoclassical theory argues that high public spending through increased investment is linked to a decline in supply of loanable funds, consequently driving-up interest rates thereby crowding-out private investment (Goldsmith, 2008). An alternative view linking public and private investments is explained by Ricardian Equivalence Theorem by Robert Barro. It argues that increase in budget deficits are accompanied by future increase in taxes, such that public investment financed by debt is to be serviced by revenue from future taxes. As a result, interest rates and private investment do not change because economic agents do not change their current level of consumption and savings since their income will only be taxed at a future date. Consequently, neither crowding-in nor crowding-out of private investment occurs and therefore, both public and private investments are independent of each other (Barro, 1978).

The other theory linking public and private investments is public capital hypothesis. The theory argues that public investment can boost private investment by increasing the returns on inputs by the private sector hence more private sector physical capital is demanded (Aschauer, 1989; Ramirez, 1994). This process according to Agenor and Moreno (2006) is known as complementarity effect. Turnovsky (1996) argues that complementarity effect occurs through the investment costs that private sector incurs when investing. For example, a good road or railway network in a given region may lower the costs incurred in setting up a factory. When the government develops key infrastructure such as roads, railways and new power stations, private sector activities may be induced due to positive spill-over effects generated from such infrastructure which boosts total factor productivity of private capital. When marginal productivity of private capital increases, the rate of returns of private investment rises, increasing their demand. Alternatively, according to the Keynesian school, crowding in effect of private investment occurs because, if an economy is below full employment, the sensitivity of investment to interest rates is assumed to be low. Therefore, increase in public investment is less likely to drive up interest rates and output expands. As a result, investors change their expectations and crowding in of private investment occurs.

Public investment can also enhance private investment by increasing their efficiency. For example, a well-developed public infrastructure facilitates trade by encouraging easier movement of goods and services, leading to reduced transportation costs and cost of acquiring private capital. This makes private sector investments more profitable and fosters private investment (Gjini and Kukeli, 2012). Private sector productivity can also be enhanced through increased public spending on education and health (Agenor et al., 2005). In contrast, if increased public investment is financed by taxes, then private sector investment may decline. Boopen and Khadaroo (2009) argue that crowding-out effect can occur if increased public investment are financed by either domestic or external borrowing. Crowding-out effect through external debt can occur if external debt servicing reduces the amount of resources available for investment. Consequently, expectations of future tax increases needed to service the debt hinder expected return on investment. In addition, Serven and Solimano (1993) link the crowding-out effect to uncertainties about future policies required to service the debt. Private investment will decline due to expected future tax increases.

Other possible transmission channels between public infrastructure and private investment are output prices (accelerator effect) and real exchange rates. As earlier explained, infrastructure development can raise the marginal productivity of factors hence raising the total productivity of the private sector capital by reducing the magical cost of production. Such effects according to Chirinko (1993) can result in more private investment through the standard accelerator effects.

Infrastructure investment can also enhance private sector investment indirectly through the real exchange rate. The overall effect on output can either be positive or negative. The rise in domestic prices can negatively impact on private investments through the reverse accelerator effect. That is, increase in domestic prices may reduce the real wealth of the private sector and expenditure and consequently lower their investments. However, on the supply-side, real appreciation of exchange rate may direct resource allocation towards the non-tradable goods sector hence promoting investments and discouraging investments in the tradable goods sector. The associated net effect is reduced output growth and less investment due to anticipated reduction in growth of demand. Conversely, if exchange rate does not fully depreciate in response the rise in domestic prices, the real cost of imported intermediate inputs decline, enhancing output and private investment.

Agenor et al. (2005) argue that the strength and direction of the impact of public investment on private investment could change over time and be influenced largely by the environment that the private sector faces. They assert that in the short-run, crowding-out effect may be experienced and in the long-run, a complementary effect. This can occur because in the short-run, there may be scarce resources available to finance private and public investment. However, in the long-term, the strong supply-side effects may enhance the complementarity effect.

Public investment can supress private investment if there is competition for resources by both public and private sectors. This can be strong especially if the government invests in public enterprises that also produce similar goods and services like the private sector, implying that the private sector faces competition from government in goods and factor markets. However, according to Grieve (2004) the savings-investment balance is solved through interest rate mechanism as explained in the loanable funds theory. Therefore, increase in infrastructure development through increased public investment results in increased interest rates which crowds-out private investment. Such arguments support the sentiments by Beck (1993) and Voss (2002). Further, according to Kustepeli (2005), public investment financed by domestic borrowing is likely to drive up interest rates, which increase the cost of credit thereby discouraging private investments.

According to Barro (1978), increased public investment on infrastructure make governments to impose more taxes in the future, decreasing disposable income and crowding-out private investments. However, increased infrastructure investments may improve the productivity of private sector investment, lower the cost of production and increase profits. The result is crowding-in effect of public investments. In the end, neither crowding-in nor crowding-out is experienced due to increased investment in infrastructure.

3.3 Empirical Literature

By applying impulse response analysis using a Vector Auto Regressive (VAR) model to analyse the effect of public infrastructure on private investment, Agenor et al. (2005) used time series data from 1980 to 2002 for 3 Middle East and North Africa (MENA) countries[14]. They established that there are relatively small significant flow and stock[15] effects of public infrastructure on private investment in MENA countries. However, they argue that infrastructure quality matters and that increasing the quantity alone does not guarantee any effect on private investment. They further note that those effects are small and transitory, indicating that the private sector faces an unfavourable environment.

Erden and Holcombe (2005) studied a panel data of developing and developed countries covering the period 1980-1997 to investigate public-private investment relationship. By applying pooled OLS and fixed effects estimators, they found that on average, a 10 percent expansion in public investment results in a 2 percent rise in private investment in developing countries, implying that public investment complements private sector investment. However,

[14]The 3 countries are Egypt, Jordan and Tunisia

[15] Flow effects are experienced via aggregate demand, relative prices and exchange rate mechanism; on the other hand, stock effects operate via market mechanism of demand and supply.

they established that public investment suppresses private investment in developed countries, linking this to disparities in capital markets in developed and developing countries.

Other studies that have employed panel approach include Ramirez (2000) who studied 8 Latin American countries between the period 1980 and 1995. The study used a pooled regression model and general least squares method to correct for positive autocorrelation and found that public investments promote private investments. Gjini and Kukeli (2012) obtained similar results by employing pooled cross-sectional data for 11 East European countries covering the period 1991-2009 using fixed effects model. They however argue that the effect diminishes as a country develops due to decreasing returns to public investment as public capital stock increases.

In a study to examine factors determining private investments, Ghura and Goodwin (2000), studied a panel of 31 countries in SSA, Latin-America and Asia using a random effects panel regression technique and pooled data for the period 1975-1992. They found that total public investment promotes private investment in SSA but has the opposite effect in Latin America and Asia. Everhart and Sumlinski (2001) obtained similar results in their study of 63 developing countries, between 1970-2000 using random effects and pooled least squares estimation. They further emphasize that crowding-out effect of public investment can become stronger with poor governance, as it lowers the quality of public investment. Bende-Nabende and Slater (2003) studied factors which promote private sector investment in Association of Southeast Asian Nations (ASEAN) countries over the period 1965-1999 using panel cointegration technique. Their findings support the crowding-out of private investment. On the other hand, Cavallo and Daude (2011) employed system GMM to solve the problem of heterogeneity and endogeneity in the model. Their results also support crowding-out of private investment in 116 developing countries they studied between 1980 and 2006. They linked this to weak institutions and inadequate access to finance in most developing countries.[16] Other studies corroborating the crowding-out theory include Voss (2002), who used a VAR model and quarterly data covering the period 1947 to 1988 for United States (US) and 1947 to 1996 for Canada. The study investigated short-and long-run relationships between the public and private investment variables and confirmed crowding-out of private investment in US and Canada.

[16]Economies with weak institutions tend to have high corruption and rent-seeking behaviour. Consequently, a unit of public sector investments in a country with weak institution results in less public services than in a country with quality institutions (see Cavallo and Daude, 2011).

By focusing on how disaggregated[17] public investment affects private sector activity, Ahmed and Miller (2000), used data from the year 1975 to 1984 for a sample of 39 developed and developing countries. They employed random and fixed estimation techniques and established that expenditure on social infrastructure stifles private investment in the two categories of countries, while spending on transport and communication increases total investment in developing countries. Pereira (2000) used time series data on disaggregated public infrastructure investment broken down into transport, energy and water and waste management systems covering the period 1956 to 1997. Using VAR approach, the study established that all forms of public infrastructure promote private investment in the United States. Supporting the findings by Pereira (2000), a study by Calderon and Serven (2002) in Latin America covering the period 1980 to 1997 found that infrastructure deficit results in lower production due to higher cost of production. They applied pooled OLS and two-stage least squares and established that the outcome is reduced economic growth due to limited investment by the private sector. Xu and Yan (2014) categorised public investment as either going to public goods and private sector in China between 1980 and 2011. They used a structured VAR model and found that state investment in public goods complement private investment significantly. On the other hand, state investment on private sector goods and industries through state-owned companies result in crowding-out of private investment.

Serven (1996) estimated a fifth order VAR error correction model for India using data covering the financial year 1960/61 to 1993/94. He found that, in the long-term, public investment in non-infrastructure projects were associated with crowding-out effect of private investment in India. This is because investment in public non-infrastructure investment acted as substitutes to those supplied by the private sector. Another evidence of crowding-out effect of public infrastructure is a study by Dong (2006) who found evidence of crowding-out of private investment in the short-run in China and complementing private investment in long-term.

Most studies supporting the contribution of infrastructure development on FDI flows have used time series data. Wekesa et al. (2017) studied the link between infrastructure expansion and FDI flows in Kenya using data from 1970-2013. By using a multiple regression approach, they found that increased investment in transport, communication, water and sewerage infrastructures positively influence FDI flows in Kenya. Bakar et al. (2012) and

[17] The authors disaggregated public investment into transport and communication, education, health and other economic affairs.

found evidence of increased FDI flow in a country due to infrastructure. In particular, sectors such as electrical and electronic sectors can serve to attract FDI into the country. To support the findings by Bakar et al. (2012), Ahmad et al. (2015) analysed the contribution of infrastructure to FDI flows in Malaysia using the ARDL method for 1980-2013 period. Their findings suggest that telecommunication infrastructure encourages FDI. Similarly, Rehman et al. (2011) employed the ARDL approach using data covering 1975-2008 in Pakistan. Their findings suggest that infrastructure strongly attracts FDI, both in the short- and long-term.

Abbas and Mosallamy (2016) established the main factors influencing FDI in MENA countries using random effects model for 2006-2013 period. The effect of infrastructure was negative and an increase in infrastructure by 10 percent led to reduced FDI flows by 5 percent. The authors attribute this to the fact that infrastructure in developing countries tend to be solely funded by the government, hence limiting opportunities for investment by foreign firms. A study by Shah (2014) found that availability of telecommunications infrastructure attracts FDIs in LDCs. Moosa (2012) investigated the determinants of FDI in 18 MENA countries using cross-sectional data. The study concluded that availability of sustainable and reliable energy systems is crucial for investors who seek efficient operations, contrasting the findings by Abbas and Mosallamy (2016).

Other studies that have applied individual-country regressions include Apergis (2000) who used cointegration analysis and found mixed results: that is, crowding-in of private investment between the 1948 and 1980 period and crowding-out between the 1981 and1986 period due to negative investors' reaction to increased public spending which resulted in lower economic efficiency and expected rise in future taxes. Narayan (2004) confirmed that public and private investments were cointegrated in Fiji using a bi-variate analysis over the 1950-1975 period. The results showed that, if public investment were increased by 1 percent, private sector investment increased by about 1.1 percent to 1.6 percent in the long-run.

3.4 Literature Overview

Theory gives different contrasting views on the link between public and private investment. Public capital hypothesis argues that public investments may increase the returns of private sector hence crowding-in (Aschauer, 1989; Ramirez, 1994; Turnovsky, 1996; Agenor and Moreno, 2006). Crowding-in can also occur when public investment increases the efficiency of private investment (Agenor et al., 2005; Gjini and Kukeli, 2012). While studies by Serven and Solimano (1993) and Boopen and Khadaroo (2009) argue that crowding-out occurs if public investment are financed by borrowing. Agenor et al. (2005) further argued that crowding-out can occur in the short-run due to scarcity of resources but in the long-run the process may be reversed through strong supply-side effects. However, Barro (1978) supports a neutral impact of public capital, such that neither crowding-in nor crowding-out is experienced.

Some studies have identified different transmission channels for crowding-in effect. Chirinko (1993) identified accelerator effect and real exchange rates as possible channels that operate via demand and supply sides. Grieve (2004) linked the channels to the loanable funds theory which operates through the interest rate channel, a phenomenon supported by Kustepeli (2005).

Empirical evidence gives varied results on whether public investment discourage or complement private investment, particularly in LDCs. Studies by Agenor et al. (2005), Narayan (2004), Ramirez (2000), and Ghura and Goodwin (2000) support the complementary effect of public investment. Other studies that have looked at the specific components of public investment and support the crowding-in effect are by Pereira (2000) and Calderon and Serven (2002). Studies that have found the crowding-out effect of public investment include Ahmed and Miller (2000), Everhart and Sumlinski (2001), Voss (2002), Cavallo and Daude (2011) and Abbas and Mosallamy (2016). Therefore, literature on how public investment affect private investment remains inconclusive and points to three main different directions which can either be crowding-out, crowding-in or no effect. The differences in the findings can be linked to model specification, methodologies and nature of data used. It is also argued that crowding-out of private investment could be experienced more in advanced economies than in developing countries. It is unclear whether governments' investment in infrastructure could crowd-out or complement private investment in EAC. Therefore, by employing panel cointegration technique, this study sought to establish how public infrastructure investment affects private investment in EAC.

A summary of the previous studies linking the relationship between public infrastructure and private investment is presented in Table 3.1.

Table 3.1: Summary of key Studies on Infrastructure and Private Investment

Authors	Data Type	Model/Methodology	Infrastructure Variables	Findings
Serven (1996)	Time series data for India. Period: 1960/61-1993/94	Fifth order VAR error correction model	Public investment in water and gas, transport and communication and electricity.	In the long-run, public investment in non-infrastructure projects has a crowding-out effect on private investment
Ramirez (2000)	Panel data for 8 Latin American countries. Period: 1980-1995	Pooled regression and generalized least squares	Public fixed capital formation	Crowding-in of private investment
Ghura and Goodwin (2000)	Panel data for 31 countries in SSA, Asia and Latin America. Period: 1975-1992	Random effects regression	Government investments	Crowding-out of private investment in SSA but not in Latin America and Asia
Ahmed and Miller (2000)	Panel data for 16 developed and 23 developing countries. Period: 1975-1984	Random and fixed estimation	Disaggregated public investment	Social infrastructure crowds out private investment in the two groups of countries while transport and communication investment crowds-in investment in LDCs
Pereira (2000)	Time series data for US. Period: 1956-1997	VAR approach	Disaggregated public infrastructure investment	All the types of public infrastructure promote private investment in the US

Apergis (2000)	Time series data for Greece. Period: 1948-196	Cointegration approach	Public investment in roads, railways and energy	Crowding-in effect for 1948-1980 period and crowding-out effect for 1981-1986 period
Everhart and Sumlinski (2001)	A sample of 63 developing countries. Period: 1970-2000	Random effects and pooled least squares estimation	Total public investment	Crowding out effect is stronger with corruption in government
Voss (2002)	Time series quarterly data for US and Canada. Period: US-1947-1988 and Canada-1947-1966	VAR model	Public investment on structures, machinery and equipment	Public investment crowds-out in private investment in US and Canada
Calderon and Serven (2002)	Panel data for 101 industrial and developing countries. Period: 1980-1997	Pooled OLS and two-stage least squares	Electricity generation, roads and main phone lines	Crowding-out effects of private investment occurs
Agenor et al. (2005)	Time series data for 3 MENA countries. Period: 1980-2002	VAR model	Infrastructure quality (Public capital efficiency) and quantity (public capital infrastructure)	Infrastructure quality is important for private investment
Erden and Holcombe (2005)	Panel data for 19 developing and 12 countries. Period: 1980-1987	OLS and fixed effects estimators	Public investment	Public infrastructure complements private investments in developing countries but crowds-out private investment in developed countries

Cavallo and Daude (2011)	Panel data of 116 developing countries. Period: 1980-2006	System GMM	Gross public fixed capital formation to GDP, paved roads and paved roads per capita (in kilometers)	Public and private investment are inversely related
Gjini and Kukeli (2012)	Panel data for 11 European countries. Period: 1991-2009	Fixed effects regression	Real gross public investment	Crowding-in effect of public investment diminish as a country develops

3.5 Methodology

This section reviews the link between public infrastructure and private investment as given by the accelerator investment theory. The associated empirical model is also discussed in this section.

3.5.1 Theoretical Framework

This section discusses the accelerator investment theory which has been adopted by this study.

Flexible Accelerator Investment Model

The model assumes that the desired capital stock varies with the level of expected output (Ramirez, 1994).

$$K_{pvt}^{*} = \alpha Y_t^e \qquad (3.1)$$

Where

K_{pvt}^{*}- Private sector's desired capital stock at time *t*; α is capital output ratio and Y_t^e- is future aggregate demand (expected output).

As a result of technological limitations and time requirements for fresh capital, the existing capital stock may sometimes not increase fully to the desired level. Following Salmon (1982), a single-period quadratic adjustment cost function to model the changes in private capital as shown.

$$\beta(K_{pvt} - K_{pvt}^{*})^2 + (1-\beta)(K_{pvt} - K_{pvt-1})^2 \qquad (3.2)$$

Where K_{pvt}– existing private capital stock (actual stock). The first term shows the cost of disequilibrium, and the second term is the adjustment costs towards equilibrium. Minimizing adjustment costs with respect to K_{pvt}results in a partial adjustment mechanism given as:

$$K_{pvt} - K_{pvt-1} = \beta({K_{pvt}}^{*} - K_{pvt-1}) \qquad 0 \leq \beta \leq 1 \qquad (3.3)$$

Where β is the adjustment coefficient. Here, existing private capital adjusts to the gap between desired private capital in the current period and actual private capital in the period before. Gross private investment is used due to limited data on capital stock for many LDCs. It is given as:

$$PVI_t = \left(K_{pvt} - K_{pvt-1}\right) + \delta K_{pvt-1} \qquad (3.4a)$$

Where δ is the rate of depreciation and PVI_t is total private investment. Rearranging Equation (3.4a) the following equation is obtained:

$$PVI_t = [1 - (1 - \delta)L]\; K_{pvt} \qquad (3.4b)$$

Where L is a lag operator given as (LK_{pvt}=K_{pvt-1}). The partial adjustment process can be given as:

$$PVI_t - PVI_{t-1} = \beta(PVI_t^{\,*} - PVI_{t-1}) \qquad (3.5)$$

Where $PVI_t^{\,*}$ is the desired gross private investment. To add more dynamics to the model, public investment and other important determinants affecting the rate of adjustment at which the difference between the desired and existing gross private investment is assumed to close up in short-run period. Therefore, a linear representation of β is given as:

$$\beta = a_0 + \left[\frac{1}{PVI_t^{\,*} - PVI_{t-1}}\right](\gamma_1 GI_t + \gamma_2 X_t) \qquad (3.6)$$

Where a_0 is a constant term, *GI* is total public investment, and X_t is a vector of other explanatory variables such as external debt, openness, private sector credit, real exchange rate and inflation rate. If public investment complements private investment, then desired private investment adjusts faster to its actual level increases and the opposite is true. Inserting (3.6) into (3.5) and rearranging, we get

$$PVI_t - PVI_{t-1} = a_0(PVI_t^{\,*} - PVI_{t-1}) + \gamma_1 GI_t + \gamma_2 X_t \qquad (3.7)$$

In the steady state, equation (3.4b) is given as:

$$PVI_t^{\,*} = [1 - (1 - \delta)L]K_{pvt}^{\,*} \qquad (3.8)$$

Plugging equation (3.1) into (3.8) and obtained equation into (3.7), and rearranging, we obtain total private investment which has public investment, and other explanatory variables as given by:

$$PVI_{i,t} = \alpha a_0[1-(1-\delta)L]Y_{i,t}^e + \gamma_1 GI_{i,t} + \gamma_2 X_{i,t} + (1-a_0)PVI_{i,t-1} + \mu_{i,t} \quad (3.9)$$

Where *i* = 1, …,N represent countries and t = 1,…,T is time dimension in panel data, and $\mu_{i,t}$ is an error term.

Equation (3.9) is a very flexible model because it expresses private investment as a function of expected level of real output and other regressors. The coefficient of Y^e gives the accelerator effect, which is positive. However, the coefficient of *GI* can have either sign depending on how substitution and complementary effects outweigh each other. On theoretical grounds, the effect of uncertainty is ambiguous, while availability of credit is expected to encourage private investment activities (Erden and Holcombe, 2005).

3.5.2 Empirical Model

Panel data analysis is employed in this study to analyse the link between public and private investment. One of the strengths of panel data methodology over time series analysis is that the former allows for heterogeneity across cross-sectional units (Baltagi, 2005). This analysis aims at establishing whether private investment is crowded-out by public infrastructure investment in the EAC. The model to be estimated is:

$$\ln PVI_{i,t} = \alpha_0 + \alpha_1 \mathrm{RIR_{i,t}} + \alpha_2 \ln ED_{i,t} + \alpha_3 \ln GDP_{i,t} + \alpha_4 ln\ OP_{i,t} + \alpha_5 \ln RER_{i,t} + \alpha_6 \ln CRE_{i,t} + \alpha_7 INF_{i,t} + \alpha_8 PBI_{i,t} + \mu_i + v_t + \varepsilon_{i,t} \quad (3.10)$$

Where

$PVI_{i,t}$-Private investment; $\mathrm{RIR_{i,t}}$-Real interest rate; $ED_{i,t}$-Ratio of external debt to GDP; $GDP_{i,t}$-Real GDP; $OP_{i,t}$-Trade openness; $RER_{i,t}$-Real exchange rate; $CRE_{i,t}$-Credit to private sector; $INF_{i,t}$-Inflation rate; $PBI_{i,t}$-Public/Infrastructure Investment; μ_i– unobserved country-specific effects; v_t–unobserved time-specific effects and$\varepsilon_{i,t}$– is the error term.

The expected signs of α_3 *and* α_6 are positive while the expected signs of $\alpha_1,\ \alpha_2$ *and* α_7 are negative, and the expected signs of $\alpha_4, \alpha_5$and α_8 is indeterminate.

3.5.3 Variables and Expected Signs

The level of desired capital stock by a firm is positively affected by a country's level of demand (Jorgenson, 1963). The aggregate demand as proxied by real GDP is an important factor influencing private investment in a country. It was expected to promote private investment in a country.

Real interest rate is a key factor influencing private investment. It reflects the cost of capital, hence the rate of return on investment. Jorgenson (1963) argues that real interest rate only affects the desired capital stock negatively but does not influence the flow of investment. Therefore, whether it should be included in an investment model remains ambiguous. Consequently, the price of capital goods relative to consumption goods is used to control for the interest rates. High private investment is expected when the relative price of capital is low. However, McKinnon (1973) and Shaw (1973) argue that real interest rates and investment volumes have a direct relationship as the former encourages savings and investments in more productive projects.

Total external debt is money owed to foreigners. In theory, external debt servicing may discourage private investment because it creates uncertainties as investors may think that taxes may be increased in the future to finance large debt service thereby leaving very little resources for domestic investments (Clements et al., 2005). High external debt levels could signal lack of commitment by the government to pursue long-term macroeconomic policies thereby creating uncertainties on future policies which negatively affects private investments. The relationship between private investment and external debt is expected to be negative.

Availability of private sector credit is essential for private sector activities particularly in LDCs (Ramirez, 1994). This can have significant effects in LDCs especially if there is serious credit rationing. As Loungani and Rush (1995) point out, most small-scale investors may not be able to access credit directly through open market debt. Thus, they resort to bank credit which poses many challenges as most commercial banks restrict credit access due to market imperfections such as information asymmetry between lenders and borrowers.

Real exchange rate affects private investment. In theory, exchange rate volatility and private investment are positively correlated. Exchange rate depreciation should increase expected profitability of capital, increasing the desired capital stock and raises the level of private investment (Hartman, 1972). According to Froot and Stein (1991), the exportable surplus would not only be reactivated by devaluation, but the acquisition of domestic assets by foreign firms would also be favorable at relatively cheaper prices. However, McCulloch (1989) argues that the rate of return determines investment but not the price of domestic asset. The connection between private investment and real exchange rate is indeterminate.

Trade liberalization, given as exports plus imports as a percentage of GDP, is another variable that is likely to affect private investment. A more open economy is likely to encourage more private investment inflows of international tradable goods which enhance growth (Balasubramanyam, et al., 1996). On the other hand, open economies can face foreign competition which can discourage foreign investment in certain segments of the economy (Serven, 2002). Further, trade liberalization can create more avenues for high capital outflows in a given country (Bibi, et al., 2012). Therefore, the priori expectation of trade is ambiguous.

In most cases, inflation rate is used to capture uncertainty in a country (Beaudry, et al., 2001). Abel (1983) argues that increased uncertainty can lead to high returns to capital which increases investments. This assertion however changes if investments are considered as irreversible (Dixit and Pindyck, 1994). According to the irreversible theory of investment, capital investments are not usually recouped by a future resale. The implication is that uncertainties that prevail in most LDCs are important in investment decisions in such countries. Therefore, on theoretical grounds, the effect of uncertainty on investment is ambiguous.

Table 3.2 describes the variables used in estimation, their measurement and sources of data.

Table 3.2: Definition of Variables, Measurement and Sources of Data

Variable	Measurement	Data Source
Private Investment	GFCF by the private sector expressed as a percentage of GDP.	WB, WDI (2020) Data Base
Real Interest Rate	It is given in percentage form.	WB, WDI (2020) Data Base
FDI	FDI inflows (net) as a percentage of GDP.	WB, WDI (2020) Data Base
External Debt	As a percentage of GDP	WB, WDI (2020) Data Base
Real GDP	Measured at constant 2010 US$	WB, WDI (2020) Data Base
Trade	Exports plus imports as a ratio of GDP	WB, WDI (2020) Data Base
Real Effective	It is measured as a value of a currency	International Monetary

Exchange Rate	against weighted average of foreign currencies expressed as a ratio of a price deflator	Fund (IMF), Africa Regional Economic Outlook
Credit to Private Sector	Domestic credit to private sector (percent of GDP)	WB, WDI (2020) Data Base
Inflation Rate	Measured by annual percentage change in consumer price index.	WB, WDI (2020) Data Base
Infrastructure Investment	Includes investment in general infrastructure	IMF's Government Finance Statistics (GFS)

3.5.5 Key Econometric Issues

This section discusses the potential econometric issues pertaining to the estimation of public infrastructure and private investments.

3.5.5.1 Test for Cross-Sectional Dependence

The test should be considered when dealing with macroeconomic data from different cross-sectional units. This is because with current levels of integration and globalization, a shock in a given country can spill-over to other countries. For example, in the EAC, any shock in Kenya such as election related violence normally affects other Partner States such as Uganda and Rwanda. Pesaran (2004) test which involves averaging of pairwise correlation coefficient generated from the ADF regressions is applied in this study.

3.5.5.2 Non-Stationarity of Variables

To prevent the problem of spurious regression, it necessary to solve for non-stationarity problem of the variables included in the model. This study uses panel cointegration to control for non-stationarity in the model.

3.5.5.3 Potential Heterogeneity across Countries

In this context, heterogeneity refers to unobservable factors that differ among individual countries but are time invariant in each country. Heterogeneity is a common problem in panel data and is addressed by allowing for short-run heterogeneity and by testing for homogeneity of long-run relationship (Calderon et al., 2011)[18].

3.5.6 Test for Unit Root

Panel unit root test is carried out to determine the stationarity of the variables. This study uses Fisher-test by Maddala and Wu (1999) and Choi (2001), Breitung (2000) test, LLC by Levin et al. (2002) and IPS by Im et al. (2003)[19].

3.5.7 Test for Panel Cointegration

It is important to test for cointegration if the variables in a given model are non-stationary. The PMG estimator can be used for estimation in the presence of cointegration. Pedroni's 2004 test for cointegration is employed in this study. It requires an estimation of a long-run relationship given by:

$$\ln PVI_{i,t} = \alpha \ln PBI_{i,t} + \beta \ln X_{i,t} + \mu_i \; + \; \delta_i t \; + \; \varepsilon_{i,t} \tag{3.11}$$

Where

$PVI_{i,t}$ −is private investment variable

$PBI_{i,t}$ −is public investment variable

$X_{i,t}$ −is the set of other explanatory variables

$\varepsilon_{i,t}$ −is the error term.

3.5.8 Pooled Mean Group Estimator

Transforming Equation (3.10) into an ARDL (p, q) model, the following equation is obtained:

$$pvi_{it} = \sum_{h=1}^{p} \alpha_{i,h}\, pvi_{i,\mathrm{t}-h} + \sum_{h=0}^{q} \lambda'_{i,h}\, \Delta X_{i,\mathrm{t}-h} + \delta_i + \varepsilon_{it} \tag{3.12}$$

Where

pvi_{it} − is private investment

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[18] A detailed explanation of the problem of heterogeneity and its solution has been highlighted in section 2.5.5.3 of this study.
[19] Refer to section 2.5.5.6 of this study for a detailed information on unit root tests used.

$X_{i,\mathrm{t}} -$ is a $k \times 1$ vector of explanatory variables

$\alpha_{i,h} -$ are scalar coefficients of the lagged private investment

$\lambda'_{i,h} -$ are $k \times 1$ coefficient vectors

$\delta_i -$ is individual specific fixed effect

Rewriting Equation (3.12) into an ECM, the following equation is obtained:

$$\Delta pvi_i = \varphi_i\left(pvi_{i,-1} - X_{i,-1}\beta\right) + \sum_{h=1}^{p-1} \alpha_{i,h}\,\Delta pvi_{i,-h} + \sum_{h=0}^{q-1} \lambda'_{i,h}\,\Delta X_{i,-h} + \delta_i t + \varepsilon_i \qquad (3.13)$$

Where

$i =$ a panel of countries, $i = 1,2,\dots,N$

$\varphi_i = -(1 - \sum_{h=1}^{p} \alpha_{i,h}),\ \alpha_{i,h} = -\sum_{m=h+1}^{p} \alpha_{i,m}$, $h = 1,2,\dots,p-1$, and

$\lambda_{ih} = -\sum_{m=h+1}^{p} \lambda_{im}$, $h = 0,1,2,\dots,q-1$.

$\beta_i = \beta\ \forall i$ is the homogeneity restriction of the long-run coefficients

$y_i = (y_{i1},\dots,y_{iT})'$ is the $T \times 1$ vector containing T observations of private investment for country *i* in the panel.

$X_i -$ is the $T \times 8$ matrix of inputs, namely public investment (PBI), real interest rate (RIR), external debt (ED), real GDP (GDP), trade openness (OP), real exchange rate (RER), credit to private sector (CRE), and inflation (INF).

$\boldsymbol{\varphi_i} -$ are coefficients capturing adjustment speed to long-run equilibrium.

$\boldsymbol{t} -$ is a vector of ones of dimension $T \times 1$

$\delta_i -$ is individual specific fixed effect

$\mathrm{E}_i = (\varepsilon_{i1},\dots,\varepsilon_{iT})'$ are the error terms which are uncorrelated across countries (*i*) and time (*t*).

In Equation (3.13), the speed of adjustment, short-run parameters and error variances varies by country. However, the long-run coefficients are restricted to be identical over the cross-section.

The long-run relationship for the variables in the model is given as:

$$pvi_{it} = \sigma' X_{it} + \gamma_{it} \quad i = 1,2,\dots,N; \quad t = 1,2,\dots,T \qquad (3.14)$$

Where

$\sigma_i = -\beta_i/\sigma_i$, is the $k \times 1$ vector of the long-run coefficients, and are non-stationary and likely to have non-zero means.

Rewriting Equation (3.14), the following equation is obtained:

$$\Delta pvi_{it} = \varphi_i \gamma_{i,t-1} + \sum_{h=1}^{p-1} \alpha_{i,h}\, \Delta pvi_{i,-h} + \sum_{h=0}^{q-1} \lambda'_{i,h}\, \Delta X_{i,-h} + \delta_i + \varepsilon_{it} \qquad (3.15)$$

In equation (3.15), the term $\gamma_{i,t-1}$is the error correction term and φ_i is the coefficient of error correction term.

Assuming the error terms follow a normal distribution, the PMG estimators from pooled maximum likelihood estimation technique are given as:

$\hat{\varphi}_{PMG} = \frac{\sum_{i=1}^{N} \tilde{\varphi}_i}{N}$, $\quad \hat{\beta}_{PMG} = \frac{\sum_{i=1}^{N} \tilde{\beta}_i}{N}$, $\quad \hat{\alpha}_{hPMG} = \frac{\sum_{i=1}^{N} \tilde{\alpha}_{ih}}{N}$, $\quad h = 1,2,\dots,p-1$ and

$\hat{\lambda}_{hPMG} = \frac{\sum_{i=1}^{N} \tilde{\lambda}_{ih}}{N}$, $\quad h = 0,1,2,\dots,q-1$, $\quad \hat{\sigma}_{PMG} = \tilde{\sigma}$

The final PMG equation estimated is given as:

$$\begin{aligned} \Delta lnpvi_{it} = {} & -\varphi_i \big(lnpvi_{i,t-1} - \sigma_1 lnRIR_{i,t} - \sigma_2 lnED_{i,t} - \sigma_3 lnGDP_{i,t} - \sigma_4 lnOP_{i,t} \\ & - \sigma_5 lnRER_{i,t} - \sigma_6 lnCRE_{i,t} - \sigma_7 lnINF_{i,t} - \sigma_8 lnPBI_{i,t} - \alpha_{m+1} t - \sigma_{0,i} \big) \\ & + \beta_{1,i} \Delta lnRIR_{i,t} + \beta_{2,i} \Delta lnED_{i,t} + \beta_{3,i} \Delta lnGDP_{i,t} + \beta_{4,i} \Delta lnOP_{i,t} \\ & + \beta_{5,i} \Delta lnRER_{i,t} + \beta_{6,i} \Delta lnCRE_{i,t} + \beta_{7,i} \Delta lnINF_{i,t} + \beta_{8,i} \Delta lnPBI_{i,t} \\ & + \varepsilon_{i,t} \end{aligned} \qquad (3.16)$$

Where:

Δ implies first difference

3.6 Results and Discussion

This section discusses the data for the variables employed in the model. Panel unit root tests are carried out to establish stationarity, further; tests for cointegration are also carried out. Regression analysis of panel data using PMG estimator is also carried out to establish how the variables in the model affect private investment.

3.6.1 Descriptive Statistics

Table 3.3 presents the descriptive statistics of variables in the empirical model.

Table 3.3: Descriptive Statistics of Variables

Variable	Min	Max	Mean	Std Dev	Skewness	Kurtosis
PVI	2.11	28.50	10.05	5.29	1.11	4.21
PBI	0.66	22.25	8.41	5.06	2.11	6.45
RIR	-16.68	24.21	8.30	7.04	-0.33	3.53
ED	13.47	175.85	60.25	39.86	1.03	3.19
RDGP	562.26	3,382.6	1,622.38	748.19	0.36	1.98
OP	19.68	72.86	42.88	11.36	0.29	2.78
RER	22.91	3,727.07	923.12	844.20	1.18	4.23
CRE	3.09	34.25	14.80	7.31	0.58	2.76
INF	-2.41	52.44	10.25	9.00	1.86	7.29

Note: *The variables PVI, PBI, ED, OP and CRE are expressed as a percentage of GDP. The descriptive summary statistics were based on 150 observations from 5 countries in EAC, from 1990-2019.*

The results indicate that the 5 EAC Partner States had an average private sector investment to GDP of 10.1 percent over the period 1990-2019. The standard deviation was 5.3 percent, implying that on average, private investment as a percentage deviates from the mean by approximately 5.3 percent. The ratio of public investment to GDP averaged 8.4 percent during the same period, while the standard deviation was 5.1 percent. Real interest rate was 7.0 percent on average while external debt was 60.3 percent of the GDP on average for the 30-year period, implying that most EAC Partner States borrow highly externally. Further, the minimum value of external debt to GDP was 13.5 percent and a maximum of 175.9 percent, this indicates that some of the EAC Partner States were highly indebted in the past. In terms of trade openness, EAC countries are fairly open, with an average openness of 42.9 percent, and ranging from 19.7 percent to 72.9 percent. Real exchange rate averaged 844.2 while growth of credit to private sector averaged 14.8 percent respectively. This implies that EAC Partner States such as Burundi, Tanzania and Uganda have relatively weak currencies that contribute to high exchange rates. For the study period, EAC Partner States demonstrated some fair level of macroeconomic stability, inflation averaged 10.3 percent. However, the minimum (-2.4 percent) and maximum (52.44 percent) indicates large variations for the different countries. Countries such as Burundi, Kenya and Tanzania seem to be highly volatile with average inflation rates of 11.2, 12.5 and 13.3 percent respectively[20]. Rwanda and Uganda had relatively stable macroeconomic environment in the review period with average inflation rates of 7.5 and 10 percent respectively.

With regards to skewness, all the variables have a positive skew except for real interest rate that has a skew of -0.33, implying that their distributions have a left tail. The rest of the variables have a distribution with long right tails implying that most of the variables have many small values and few large values. This means that most of the variables experienced very low growth rates during the period under consideration. The kurtosis is the standardized fourth population about the mean and shows the variables' distributions in terms of peakedness. Real GDP, openness and credit to private sector have a kurtosis which is less than 3, a Platykurtic distribution. The rest of the variables, that is: real interest rate, private investment, public investment, external debt, real exchange rate and inflation have kurtosis which is greater than 3, a Leptokurtic distribution.

3.6.3 Correlation Results

Table 3.4 shows the correlation between each pair of variables in levels.

Private and public investments are positively correlated. However, the degree of correlation is moderate, suggesting potential crowding-in of private investment in the EAC. This is because public investment should create a conducive environment for private investment. However, private investment and external debt have negative correlation. This could be due to higher taxes that might be imposed to service the external debt which can discourage private investment.

[20]Refer to Table E1 in the appendix for individual country descriptive statistics.

Table 3.4: Correlation Matrix of Variables in Levels

	LPVI	LPBI	RIR	LED	LRGDP	LOP	LRER	LCRE	INF
LPVI	1								
LPBI	0.45**	1							
RIR	0.11	-0.06	1						
LED	-0.35**	0.04	0.37	1					
LRGDP	0.66**	0.41**	0.13	-0.39**	1				
LOP	0.41**	0.20	0.19	-0.23**	0.56**	1			
LRER	0.31**	0.23**	0.01	-0.19	-0.24**	-0.23**	1		
LCRE	0.20	0.25**	-0.34**	-0.28**	0.39**	0.45**	-0.37**	1	
INF	-0.16	-0.22**	0.45**	0.36**	-0.08	0.15	-0.25**	-0.15	1

*** and * Indicate statistical significance at the 1 percent level (2-tailed) and 5 percent level (2-tailed) respectively*

Private investment has a positive correlation with economic growth in the EAC (Table 3.4). This is because as the economy grows, many opportunities arise, and the income level of the population is likely to rise hence stimulating more private investment. Private investment and openness also have a statistically significant positive correlation, this is because more open economies attract foreign investment in the economy. There is a positive correlation between private investment and real exchange rate in EAC. This is because exchange rate appreciation can result in cheaper importation of capital equipment by the private sector.

3.6.4 Econometric Tests

This section presents the econometric tests that were conducted before estimation.

3.6.4.1 Test for Cross-Sectional Dependence

Both Pesaran's (2004) and Breush-Pagan Lagrange Multiplier (LM) are employed in this study. The results are given in Table 3.5.

Table 3.5: Tests for Cross-Sectional Dependence

	Pesaran's Test of Cross-Sectional Independence	*P*-Value
Pesaran CD test	-0.552	0.5092
Average absolute value of the off-diagonal elements	0.159	
Breusch-Pagan LM test of Independence		
$\chi^2(10)$	13.172	0.2142

From the results, the null hypothesis is accepted at 5 percent level of significance, hence no CD. This implies that the residuals across entities are not correlated. Therefore, tests for panel unit-root tests such as IPS, LLC and Fisher can still be applicable to test for stationarity.

3.6.4.2 Test for Panel Unit Root

The results of the panel unit root tests for the variables are summarized and presented in Table 3.6.

From Table 3.6, the variable, real interest rate (RIR) was stationary at level in all tests, this means that the series does not contain a unit root and therefore I (0). However, variables RER, CRE and INF were stationary under LLC tests and non-stationary for Breitung and Hadri LM tests. Inflation was found to be stationary by all tests, except Breitung and Hadri. From this, it was concluded that the series is stationary and therefore, are I (0). However, the variables LPVI, LPBI, LED, LRGDP, LOP and LCRE were found to be non-stationary by majority of the tests, although they were all found to be stationary after first difference, hence are I(1). Since the variables are either I(1) and I(0), PMG estimator is still appropriate in this case since no variable is of I (2).

Table 3.6: Tests for Panel Unit Root

Null Hypothesis: Panels contain unit roots

Methods		**LLC**	**IPS**	**Fisher-ADF**	**Breitung**	**Hadri LM**
Variable		**Statistic**	**Statistic**	**Statistic**	**Statistic**	**Statistic**
Level	LPVI	0.10	-1.44	-1.63	0.00	26.4***
	LPBI	0.77	0.44	0.65	-1.44	28.0***
	RIR	-3.72**	-4.78***	-7.90***	-8.31***	1.58
	LED	-0.64	0.78	0.93	0.06	25.23***
	LRGDP	0.21	5.30	4.73	5.19	36.62***
	LOP	-0.63	-0.55	-0.67	-1.17	16.46***
	RER	-3.88***	3.26	8.70	3.15	35.66***
	LCRE	-2.01**	-0.38	-0.40	0.94	30.19***
	INF	-2.43***	-3.94***	-5.58***	-1.07	9.80***
1st Difference	ΔLPVI	-4.97***	-5.47***	-12.05***	-5.58***	-0.74
	ΔLED	-3.52***	-5.17***	-9.57***	-5.51***	0.41
	ΔLRGDP	-3.03***	-3.77***	-6.38***	-3.28***	1.48
	ΔLOP	-6.06***	-6.20***	-16.96***	-6.36***	-1.47
	ΔLCRE	-6.38***	-6.59***	-20.32***	-4.72***	0.71

**** and ** indicate statistical significance at one and five percent respectively, L-denotes the natural log and* $\Delta -$ *denotes first difference. All the variables are as earlier defined.*

3.6.4.3 Panel Cointegration Tests

The next step after unit roots test is to explore for cointegration among the I(1) variables. Kao (1999), Pedroni (2004), and Johansen Fisher panel tests are applied in this case. Pedroni cointegration tests are given in Table 3.7.

Table 3.7: Pedroni Cointegration Test Results

Null Hypothesis: No cointegration

Test Statistic	Statistic	P-Value
Within Group		
Panel V-Statistic	-1.2090	0.8867
Panel Rho- Statistic	0.9698	0.8339
Panel PP- Statistic	-2.7301***	0.0032
Panel ADF- Statistic	-2.8170***	0.0024
Between Group		
Group rho-Statistic	1.1120	0.8669
Group pp-Statistic	-4.5737***	0.0000
Group ADF-Statistic	-2.7523**	0.0030

*Note: *** and ** Indicate that parameter is statistically significant at 1 percent and 5 percent respectively*

From the results, the null hypothesis is rejected by majority of the tests in Table 3.7. Evidence from Monte-Carlo simulations suggest that both Panel- and Group- ADF are the most reliable and effective tests for cointegration. However, Orsal (2008) finds Pedroni's panel t-statistic as the best in terms of size and power compared to other tests.

Table 3.8: Kao Test for Cointegration Results

Null Hypothesis: No cointegration

	t- Statistic	P-Value
ADF	-2.4346	0.0075
Residual Variance	0.0592	
HAC Variance	0.0253	

The null hypothesis is also rejected by Kao's test for cointegration (Table 3.8). Table E2 in Appendix E shows Johansen Fisher panel cointegration test results, also confirming cointegration. It can therefore be concluded that there is cointegration in the private investment model.

3.6.5 Regression Analysis Results

PMG was used in the regression. For the PMG estimator, it is possible to include both I (0) and I (1) variables in a regression. Since PMG is sensitive to choice of lag length, regression was done based on ARDL dynamic specification of the form (1, 1, 1, 1, 1, 1, 1), which was obtained from Akaike information criterion. The long-run regression results between public infrastructure and private investment are presented in Table 3.9.

Table 3.9: Long-run PMG Estimation Results

Dependent Variable: Private Investment				
Variable	Coefficient	Std. Error	t-Statistic	P-Value
LPBI	0.3869***	0.0874	4.4291	0.0000
LRGDP	0.7281**	0.2952	2.4663	0.0155
LOP	-1.0534***	0.3021	-3.4863	0.0008
LCRE	0.5557**	0.2142	2.5946	0.0110
LED	0.0042	0.0770	0.0551	0.9562
RIR	-0.0038	0.0084	0.4601	0.6465
RER	0.0001	0.0001	0.8398	0.4032
INF	0.0052	0.0070	0.7489	0.4558
No. of Obs.	145	Mean dependent	var 0.0367	
S.E of regression	0.1644	S.D. dependent	var 0.2452	
Log Likelihood	94.1666			

***** and ** indicate statistical significance at one and five percent respectively*

Table 3.9 gives the PMG estimates of private investment for the long-run model. In the long-run, public infrastructure investments complement private investment. An expansion of public investment by 10 percent results to a 3.9 percent increase in private investment. These findings support the Keynesian theory of crowding-in of private investment and the public capital hypothesis theory by Aschauer (1989) and Ramirez (1994) which argue that increase in public infrastructure investment encourage private sector investment. This process according to Agenor and Moreno (2006) is referred to as complimentarity effect. The results support studies by Ramirez (2000), Ghura and Goodwin (2000), Narayan (2004), Erden and Holcombe (2005), Dong (2006) and Gjini and Kukeli (2012) but contrasts those of Voss (2002), Bende-Nabende and Slater (2003) and Cavallo and Daude (2011) who corroborate the crowding-out theory. Private investors are usually attracted to regions with well-developed infrastructure systems hence the positive relationship in the EAC.

The argument by the accelerator theory is that the coefficient of real GDP should be positive to capture the accelerator effect, implying that real GDP positively affects private investment. From this study, real GDP is one of the key drivers of private investment in the EAC in the long-run. If the economy grows by 10 percent, then private investment increase by 7.3 percent. The positive link between private investment and real GDP is such that, high economic growth reflects an overall economic stability thereby encouraging more private sector investment since overall business confidence rises. On the other hand, low real GDP growth reflects a poorly performing economy and is likely to scare away private investors. These findings are therefore, as hypothesized and consistent to the accelerator theory of investment. This indicates the vital role of aggregate demand in stimulating private investment in an economy.

Another important factor affecting private investment in the EAC is openness. Openness negatively affects private investment in the EAC such that a 10 percent increase in trade openness results in a 1.1 percent drop in private investment in the long-run. Foreign competition can affect the profitability of domestic investment thereby discouraging further private investment. Serven (2002) argues that high foreign competition can discourage private investment in some sectors of the economy. According to Bibi et al. (2012), open economies can be avenues for capital flight, hence a negative effect on private investment.

Domestic credit to private sector promotes private investment in the long-term. Access to finance is important for the private sector to acquire credit for investment. An growth in domestic private sector credit by 10 percent in EAC results in 5.6 percent increase in private investment. From the findings external debt, real exchange rate and inflation have positive but not statistically significant impact on private investment in the long-run. In the long-term real interest rate exhibits negative but not statistically significant effect on private investment in the EAC.

Table 3.10 presents the short-run regression results for the relationship between public infrastructure and private investment.

Table 3.10: Short-run Model PMG Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	P-Value
ECT_{t-1}	-0.3355***	0.1195	-2.8066	0.0061
$d\text{LPBI}_{t-1}$	-0.3122**	0.1222	-2.554	0.0123
$d\text{LRGDP}_{t-1}$	0.0815	0.3058	0.2666	0.7904
$d\text{LOP}_{t-1}$	0.0690	0.2731	0.2527	0.8010
$d\text{LCRE}_{t-1}$	-0.1283	0.1074	-1.1946	0.2353
$d\text{LED}_{t-1}$	-0.0619	0.0735	-0.8423	0.4018
$d\text{RIR}_{t-1}$	-0.0025***	0.0011	-2.2727	0.0071
$d\text{RER}_{t-1}$	-0.0038	0.0030	-1.2945	0.1987
$d\text{INF}_{t-1}$	-0.0029***	0.0009	-3.1962	0.0020
Constant	-0.3726***	0.1412	-2.6392	0.0098
No. of Obs.	145	Mean dependent	var 0.0367	
S.E of regression	0.1644	S.D. dependent	var 0.2452	
Log Likelihood	94.1666			

*Note: ECT-Error correction term and dX_i-Implies that variable has been differenced. *** and ** indicate statistical significance at one and five percent respectively*

The short-run PMG regression is presented in Table 3.10. The model is significant since the lagged error correction term is negatively signed as required. Its coefficient indicates the rate of adjustment to equilibrium in a given year. From the findings, 33.6 percent of disequilibrium long-run equilibrium are corrected per year. This implies that not all deviations are corrected yearly, an indication that EAC economies are operating in disequilibrium in most cases. Therefore, full adjustments would take about 3 years.

In the short-run, increase in infrastructure investment suppresses private investment in the EAC. If the government increases public infrastructure investment by 10 percent, private investment fall by 3.1 percent one year later. This may occur if the government's infrastructure investment is financed by domestic resources thereby driving up real interest rates which discourages private investment. From the results in the short-run, private investment has a negative statistically significant relationship with real interest rates in EAC. A 10 percent rise in real interest rates results in a decrease in private investments by 0.025 percent in the subsequent year. This implies that high real interest rates in the past stifle present private investment. Therefore, private investment is crowded-out via interest rates in the EAC. These results are consistent to findings by Dong (2006) who found that in the short-term public investment stifles private investment in China but complements it in the long-term.

Inflation is another short-term factor affecting private investment in the EAC. A rise in the general price level by 10 percent results in a 0.03 percent fall in private investment in EAC one year later. Since the variable was lagged once, it implies that high inflation levels in the previous year discourage present private investment. This is because private investors might form expectations that high inflation levels in the previous year might continue to the present year hence discouraging private investment in the current year.

The impact of the rest of the variables, real GDP and trade openness on private investment is positive, albeit not statistically significant. The impact of private sector credit, real interest payments on real exchange rate and external debt on private investment is negative though not statistically significant in the short-term.

Granger Causality Test

Since the I(1) variables were cointegrated, Granger causality test was conducted to determine the causal relationships between the variables in the model. Table 3.11 presents the Granger causality tests that were conducted between public infrastructure and private investment.

Table 3.11: Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	P-Value
LPBI does not Granger LPVI	125	2.3943	0.0428
LPVI does not Granger LPBI		2.3129	0.1034
LRGDP does not Granger LPBI	125	0.8132	0.5430
LPBI does not Granger LRGDP		5.0650	0.0004

The tests results in Table 3.11 imply that the null hypothesis that public infrastructure investment does not granger cause private investment is not accepted. This implies that there is a causal relationship between public infrastructure investment and private investment. In addition, public infrastructure investment indirectly impacts private investment through the aggregate demand channel (real GDP) known as the accelerator effect. This is shown by the unidirectional long-run causality from public infrastructure investment to economic growth (real GDP).

3.7 Summary, Conclusion and Policy Implications

3.7.1 Summary

The study investigates the role of public infrastructure investment in influencing private investments in EAC over a 30-year period (1990 to 2019) by employing Pedroni's panel cointegration methodology. All cointegration tests, Pedroni, Kao and Johansen Fisher revealed the presence of a cointegration. Using a PMG estimator, the results reveal that, in the long-run, public investment crowds-in private investment in the EAC. The findings are consistent with public capital hypothesis which supports the crowding-in of private investment. This implies that, one of the channels through which public investment impacts economic growth in the EAC is private investment. The study conducted Granger causality tests which revealed a uni-directional long-run causality exists between public investment and private investment. Further, there is a uni-directional causality relationship from public infrastructure investment to economic growth, implying that public infrastructure investment also affects private investment indirectly through increase in real GDP.

From the ECM, a negative relationship between private investment and public infrastructure investment exist in the EAC, implying crowding-out effect. This is manifested in the negative association between private investment and real interest rates in the short-term. Therefore, past increases in public infrastructure investment depresses current private investment in the EAC. However, the long-run positive effect of public infrastructure is stronger than the negative short-run crowding-out effect.

Further, according to the findings of this study, real GDP is another important long-term driver of private investment in the EAC. A stable economic progress is an indication of macroeconomic stability which makes the investment climate favourable. This occurs through the accelerator effect. In theory, a rise in public investment leads to an increase in aggregate demand, thereby stimulating private investment. Therefore, in the long-term, public investment can be said to positively influence private investment indirectly via the accelerator effect.

The study however, established that in the long-run, external debt, real exchange rate, real interest rate and inflation do not inform private investment decisions in EAC. However, in the short-run, real interest rate and inflation affect private investment while real GDP, trade openness, private sector credit, external debt and real exchange rate have no impact private investment in EAC.

3.7.2 Conclusion

From the findings, this study concludes that public infrastructure investment, economic growth, credit to private sector and openness to trade are important determinants of private investment in the EAC. Public infrastructure investment plays a significant role in private investment decisions in that it creates a favourable environment for private investors to operate in. In particular, most EAC governments have been investing more in transport and energy sectors which are critical for private investors as they lay a fundamental base for most economic activities in any given country. High economic growth symbolises strong aggregate demand in a country which is key in attracting private investment in the long-term.

The findings of this study confirmed that in the EAC, high trade openness has negative effect on domestic private investment due to increased competition from foreign firms. In the short-run, crowding-out of private investment occurs in the EAC and a high level of inflation in the past dampens current private investment.

3.7.3 Policy Implications

The findings of this study have key policy implications, particularly in the EAC context where huge infrastructure spending has been experienced in the last decade. Since the results confirm a complementary effect of public infrastructure investment, it is therefore crucial for governments in the EAC to continue with the expansion of infrastructure projects to create a favourable environment for the private sector and enhance growth. That is, more government resources should be channelled to sectors that promote the complementary effect of public investment, hence increasing private investment in EAC.

Access to domestic credit would boost private investment in EAC. It is therefore, important for the Partner States in EAC to ensure that credit is affordable for the private sector to encourage more investment by the private sector. This can be done by proper regulation of the financial sector to ensure a healthy competition by the commercial banks in these economies.

Openness impacts negatively on private investment in the long-term. This is due to lack of competitiveness of domestic firms attributed to inadequate infrastructure. Hence it is important for EAC Partners States to provide the necessary infrastructure to lower the cost of production of the private sector and boost their competitiveness internationally in order to minimize unhealthy competition emanating from foreign firms.

Inflation and interest rates have negative effect on private investment in the EAC. It is therefore, important for the governments in EAC to pursue appropriate fiscal and monetary policies that ensure macroeconomic stability by ensuring that interest rates and inflation levels are maintained at moderate levels. In addition, there is need to minimize borrowing from the domestic market to finance public investment to reduce the short-term crowding out. Consequently, high economic growth can be realized which then promote activities of the private sector in the long-term.

ESSAY THREE

INFRASTRUCTURE DEVELOPMENT, INTRA- AND INTER-EAC TRADE

4.1 Introduction

This essay investigates the connection between infrastructure and intra-and inter-EAC trade. In this study, intra-EAC trade refers to trade among the 5 EAC Partner States while inter-EAC trade refers to trade between the EAC and 3 RECs in SSA namely SADC, ECOWAS and the Economic Community of Central African Sates (ECCAS). The essay introduces briefly, the nature of intra-and inter-EAC trade and reviews recent research on infrastructure and trade. Section 2 reviews various theories linking trade and infrastructure. Section 3 discusses empirical literature which focuses on the recent empirical studies on various measures of infrastructure and trade. Section 4 is an overview of entire literature and focuses on the weaknesses and gaps of the previous studies. Section 5 describes the methodology employed in the study while Section 6 discusses the study findings. Lastly, section 7 gives a summary, conclusions and policy implications of the study.

4.1.1 Intra-EAC Trade

Regional trade integration is a key objective of EAC Partner States. The EAC has put measures such as joint infrastructure policy and other trade facilitation measures all aimed at promoting exports within and outside the region. The value of EAC bilateral trade between 1990 and 2019 was US$ 37,278 million (Table 4.1).

Kenya controls the largest proportion of intra-EAC trade. For the study period, the share of Kenya’s bilateral exports to other EAC counterparts was 50.1 percent. Uganda and Tanzania come second and third respectively with trade shares of 21.9 percent and 20.3 percent respectively. Rwanda controls 6.8 percent of trade in EAC. This is a relatively smaller share as compared to Uganda and Tanzania. Burundi has the smallest share of trade in the EAC at 0.9 percent (Table 4.1).

Table 4.1: EAC Total Bilateral Exports, 1990-2019 (US$ Million)

		Importer						
		BDI	KEN	RWA	TZA	UGA	Total Exports	Export Share (percent)
Exporter	BDI		165.90	91.60	41.10	53.72	352.31	0.9
	KEN	837.86		2,347.64	5,397.48	10,096.25	18,679.22	50.1
	RWA	206.90	1,265.28		689.74	384.12	2,546.05	6.8
	TZA	626.61	4,462.78	1,336.51		1,121.45	7,547.36	20.3
	UGA	638.67	4.358.18	2,486.08	670.01		8,152.94	21.9
Total Imports		2,310.05	10,252.14	6,261.83	6,798.32	11,655.54	37,277.88	100

Source: Author's Computation using data from COMTRADE[21]

Kenya and Tanzania are the only net exporters within the EAC. For the study period, Kenya's exports totalled US$ 18,679 million and imports were worth US$ 10,252 million, indicating a trade surplus worth US$ 8,427 million. Tanzania exports were worth US$ 7,547 million and imports totalled US$ 6,798 million, hence a surplus of US$ 749 million. Rwanda had the largest trade deficit in EAC valued at US$ 3,716 million followed by Uganda with US$ 3,503 million. Burundi had deficit worth US$ 1,958 million.

4.1.2 Inter-EAC Trade

EAC Partner States have also been trading with other RECs in SSA such as SADC, ECOWAS and ECCAS. The total value of exports from EAC to the 3 RECs totalled US$ 32,906.71 million between 2000 and 2018. Figure 4.1 shows the trend of exports from EAC to other RECs in SSA for selected years between 2000 and 2018.

EAC trades more with SADC compared to ECOWAS and ECCAS (Figure 4.1). The value of exports from EAC to SADC increased to US$ 1,644.61 million in 2018 from US$ 176.6 million in 2000. The EAC also trades relatively more with ECCAS compared to ECOWAS. The value of exports from EAC increased from US$ 64.15 million in 2000 to US$ 739.01 million in 2018. EAC trades less with member states of ECOWAS, with exports to the region standing at US$ 58.0 million in 2018.

[21]Data from COMTRADE is accessed through World Integrated Trade Solutions (WITS), produced by the World Bank. Data accessible at https://wits.worldbank.org/

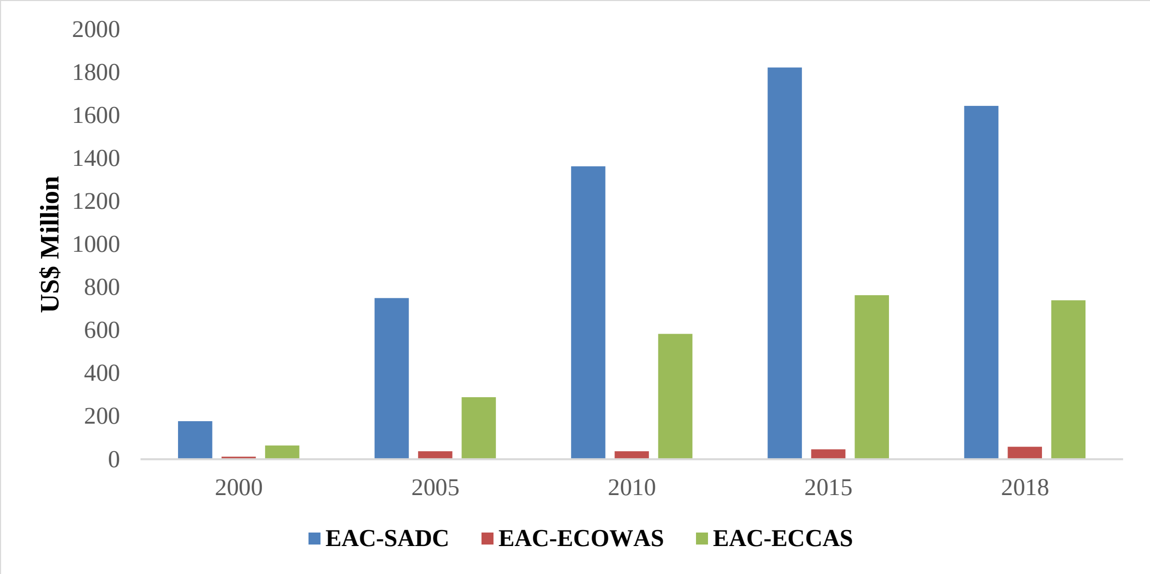

Figure 4.1: EAC's Exports to other RECs in SSA (US$ Million)

4.1.3 Role of Infrastructure in Trade Facilitation

With increased competition in the international markets, firms have to adjust their production and management systems to ensure that delivery of goods is timely, reliable and flexible (Mbekeani, 2007). In Africa however, limited infrastructure and poor transport network hinders firms from participating in international trade since they cannot ensure timely delivery of goods to enable reliable supply of goods. However, some of the delays in delivery of goods can also be attributed to dilapidated infrastructure in both transit and exporting countries and non-tariff barriers. Since delays can be experienced outside the border of a given country, it becomes difficult for a single country to overcome all the trade related obstacles.

Consequently, high transport costs resulting from poor infrastructure escalate the prices of intermediate inputs and capital, resulting in high cost of agricultural and manufactured output in the domestic market (Mbekeani, 2007). In comparison to other regions globally, Africa and Oceania have the highest international costs of transport as a share of the import value for all modes of transport (Figure 4.1). The American region had successfully reduced the cost of freight[22] (as a percentage of import value) by 3 percentage points, from 11 percent between 1985 and 1994 to 8 percent between 2015 and 2018. Likewise, developed economies managed to lower their transport costs by 2.8 percentage points, that is, from 9.5 percent of

[22]Freight Costs refers to all the costs necessary to transport goods to a given transport destination.

import value in 1985-1994 to 6.7 percent in 2015-2018 periods. However, in Africa, the ratio of freight costs to value of imports decreased only by 1.2 percentage points, from 12.4 percent in 1985-1994 to 11.2 percent in 2015-2018 periods. The Asian region managed an average cost of freight of 9 percent between 1985-1994 periods to 2015-2018 periods.

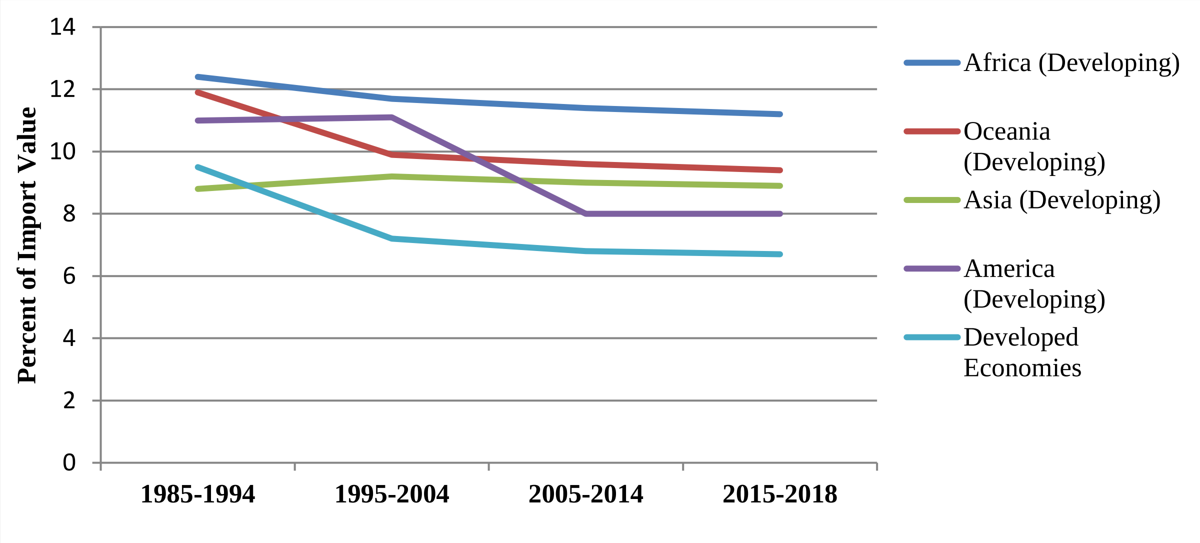

Figure 4.2: Freight Costs by Regional Average (as percent value of imports)

Source: United Nations Conference on Trade and Development (UNCTAD), Review of Maritime Transport 2015 and 2018

The proportion of transport costs in import in total import value can be a pointer of the effect of transport costs on participation in international trade by countries. For African economies, the freight costs are as high as 11 percent of the import values, compared to about 7 percent for the developed countries (Figure 4.2). UNCTAD (2015) estimates that developing countries in Africa and Oceania pay 40 to 70 percent higher than developed economies for international transport of imports. Therefore, infrastructure development would significantly lower cost of transport of imported goods thereby encouraging production in the domestic market, promote diversification rates by creating new opportunities for investment and enhance the competitiveness of exports from Africa.

Even though African countries pay more than 40 percent higher than developed economies to import, the proportion of imports in GDP tend to be higher than that of exports. Between 2010 and 2019, EAC's proportion of imports in GDP was twice that of exports (Table 4.2). Further, exports as percent of the GDP reveal a downward trend, implying that EAC economies are not performing well in international trade. Infrastructure development is important in international trade, according to logistic performance index[23] (LPI) based on quality of trade and transport infrastructure by World Bank. The EAC average was 2.2, which is below the average of 2.5 and the recommended level of 3. This reflects high trade costs in the EAC which then affects products' competitiveness.

Table 4.2: EAC Exports and Imports (Percent of GDP), 2010-2019

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Exports	15.0	15.6	16.4	15.7	14.6	13.7	13.1	14.3	14.2	14.9
Imports	28.8	32.7	32.0	31.7	27.8	25.8	22.3	24.0	26.2	28.8

Source: World Bank (2020) World Development Indicators,

According to Limao and Venables (2001), on average, for a landlocked country transport costs are 50 percent more than that of a non-landlocked country. In addition, their volume of trade is 60 percent lower. Africa has 15 landlocked countries out of 54, while the EAC has 4 landlocked countries (including South Sudan). These countries must rely on the coastal transit countries such as Kenya and Tanzania to access the ports and world markets. Therefore, transport systems in these countries are important to the landlocked countries in the region. This study therefore investigates how infrastructure stock and quality affects both intra-and inter-regional trade. These include transport, ICT, and soft infrastructures.

Section 4.1.4 gives the research question related to this essay. Therefore, for clarity on the focus of this essay, the specific research questions are presented.

4.1.4 Research Questions

This essay sought to answer these questions.

(i) What is the impact of transport infrastructure on intra-EAC trade?

(ii) How does ICT infrastructure contribute to intra-EAC trade?

(iii) What is the role of soft infrastructure in determining intra-EAC trade?

(iv) How do transport infrastructure and institutions affect inter-EAC trade in SSA?

[23]LPI is constructed by World Bank based on expert surveys and ranges from 1 (low) to 5 (high). It includes custom procedures, cost of logistics and infrastructure quality for overland and maritime transport. A value of less than 3 indicates a problem with a country's freight distribution system resulting in unnecessary delays and additional transport costs.

4.1.5 Objectives

This essay seeks to:

(i) To analyse the impact of transport infrastructure on intra-EAC trade.

(ii) To determine the contribution of ICT infrastructure to intra-EAC trade

(iii) To investigate the role of soft infrastructure in determining intra-EAC trade

(iv) To analyse the impact of transport infrastructure and institutions on inter-EAC trade in SSA.

4.2 Theoretical Literature

Gravity model has gained popularity in modelling international trade flows. The model applies Newton's law of gravity. The model is attributed to Tinbergen (1962) who applied to analyse bilateral trade flows. It is represented as:

$$TR_{ij} = C\frac{Y_i Y_j}{D_{ij}}$$

Where

C −is a constant; TR_{ij} −Total trade flow from country i to country j; $Y_i$and Y_j − are incomes in country i and country j and D_{ij} − Geographical distance in kilometres, between country *i* and country j.

Transport costs are captured by distance in the gravity model. The model therefore, indicate that countries with large economic size trade more and that trade costs between two trading partners reduce trade between them.

Trade costs are heavily determined by infrastructure development, this has been given more attention in modern literature (De, 2006; Mbekeani, 2007; Bensassi et al., 2014). Trade costs vary from one country to another. However, average trade costs for African countries seem to be higher than most countries around the world. Trade costs hinder the participation of EAC Partner States in international trade. This is linked to lack of well-developed infrastructure and poor-quality institutions.

Even though efforts have been made to minimize tariffs globally, many trade barriers still exist. De (2006) categorizes the barriers into soft and hard. The soft barriers refer to administrative measures and custom regulations that are related to cross-border trade. To eliminate the soft barriers, trade facilitation measures such as reducing the required documentation and regulations are always applied. On the contrary, hard barriers are usually related to infrastructure, hence eradicated through transport facilitation actions.

The effect of infrastructure on trade costs and volume has been examined by previous studies. Recent evidence has given attention to institutions and trade flows. For example, Levchenko (2004) asserts that differences in quality of institutions can create comparative advantage which is a crucial determinant of trade flows. Chang et al. (2005) assert that institutions and infrastructure are crucial for trade and countries that are performing poorly in trade and growth could be linked to dilapidated infrastructure and weak existing institutions. Trade costs are known to negatively impact on trade flows, a phenomenon described by iceberg melting model by Samuelson (1954). Infrastructure development serves to improve trade flows by lowering trade costs.

Bougheas et al. (1999) were first to augment gravity model for infrastructure variables from the 1997 Dornbusch-Fischer-Samuelson model. This was done in a study of European countries linking infrastructure and trade. The authors found that the differences in stock and quality of infrastructure explained disparities in trade volumes and competitiveness witnessed across countries. They further linked increased trade flows to infrastructure development due to reduced trade costs. The sentiments are supported by Francois and Manchin (2006), Wilson et al. (2008) and Celbis et al. (2014) who point out that development of physical infrastructure can increase a country's trade levels by lowering the cost of transporting goods. According to Henckel and McKibbin (2010) improved infrastructure can also lead to expansion of markets and consumers benefiting from different competing producers which lead to low prices and better welfare outcomes.

High trade costs can limit both domestic and cross-border trade. Time taken to transport goods between two destinations, to acquire information and to implement agreements have implications on trade volumes (Nordas and Piermartini, 2004). The authors further argue that bilateral trade is likely to be enhanced by quality institutions and good communication infrastructure which act by lowering trade costs. As postulated by Anderson and van Wincoop (2004), infrastructure could have significant effect on time costs associated with trade hence good infrastructure would promote trade.

Increased export performance is linked to well-developed infrastructure services particularly transport infrastructure. Infrastructure is significant in determining trade costs. According to Limao and Venables (2001), poor infrastructure explains approximately 40 percent of transport costs for non-landlocked countries and about 60 percent for landlocked countries. The authors further argue that countries with dilapidated infrastructure can reduce transport costs by 30 percent by upgrading to the 25^{th} percentile from 75^{th} percentile. The authors also analysed the role of infrastructure of the exporter, importer, and transit countries and established that all the three categories of infrastructure promote bilateral trade. However, Longo and Sekkat (2004) findings place a caveat on the conclusion by Limao and Venables (2001) by arguing that the effect of exporter and importer infrastructures may not act symmetrically for two trading countries who have distinct economic features. They concluded that both importers and importers infrastructure promote intra-Africa trade but not inter-Africa trade, in particular, between Africa and developed countries.

Infrastructure development can also foster trade and regional integration (Clark et al., 2004). A well-developed infrastructure is necessary for investments, trade and enhancing regional competitiveness of an economy. This occurs because a good infrastructure network enhances the movement of goods, services and individuals across nations. In addition, a good infrastructure network encourages information flow which encourages trade.

4.3 Empirical Literature

In a study of 10 Asian countries, Ismail and Mahyideen (2015) augmented a gravity model to include different forms of infrastructure. They employed random effects estimation using data between 2003 and 2013. Their findings reveal increased volume of trade as a result of improving the quality transport infrastructure. These findings corroborate the findings by Hernandez and Taningco (2010) who used data 11 Asian countries on imports between 2006 and 2008. Using fixed effects model, their findings linked trade in East Asia to the state of port infrastructure particularly for petroleum products, investment goods, consumption and industrial supplies. A similar study based on gravity model was conducted by Shepherd and Wilson (2009) between 2000 and 2005 for 14 economies in ASEAN using OLS technique. Their findings revealed that ICT and transport infrastructures are the most important facilitators of trade in ASEAN.

The role of physical infrastructure in enhancing the volume of exports is also supported in a study by Portugal-Perez and Wilson (2012) for a sample of 101 LDCs for the period 2004 and 2007. Using Heckman selection model, the study established that hard infrastructure is a key driver of exports but with a declining effect as income level increases. Martincus and Blyde (2013) used difference in difference estimator to analyse how domestic transport infrastructure affects Chile's exports using data for the period 2008 and 2011. They employed firm-level data and found that domestic infrastructure shocks have negative impact on the exports by firms. A different study by Francois and Manchin (2006) further emphasized the important contribution of transport infrastructure to trade facilitation. They concluded that communication and transport infrastructures and institution type are the main determinants of a country's exports and ability to export.

Wilson et al. (2005) employed an OLS estimator to estimate a gravity model for 75 countries to determine the linkage between manufactured exports and trade facilitation over the period 2000-2001. Using four measures of infrastructure facilitation, namely service sector infrastructure, port efficiency, customs and regulatory environments, they established that huge gains are obtained from unilateral trade facilitation especially in exports. Specifically, improvement in port efficiency and customs environment could increase trade in manufactured products by US$ 107 billion and US$ 33 billion respectively. Similarly, improvement in service-oriented infrastructure and regulatory environment increases trade by US$ 83 billion and US$ 154 billion respectively. Similarly, Sologoa et al. (2006) applied a gravity model in Mexico and established that upgrading of various trade facilitation measures by a country could enhance manufactured exports by US$ 31.8 billion.

Other studies linking manufactured exports to infrastructure development, include, Soloaga et al. (2006) who applied gravity model and found that improving unilateral trade facilitation measures could increase Mexico's manufactured exports by US$ 31.8 billion. Shinyekwa and Ntale (2017) examined the connection between infrastructure and exports of manufactured goods in EAC using a gravity model. By employing a random effects method, they found that boosting hard infrastructure stock has more potential to increase the exports of manufactured goods as compared to soft infrastructure. Cosar and Demir (2015) investigated the role of domestic infrastructure in promoting province-level manufacturing exports in Turkey between 2003 and 2012. Using instrumental variable estimation method, they found that the average transportation cost of goods over a highway is approximately 70 percent less compared single-lane roads.

Using various measures of trade facilitation for specific countries country-specific data for Asia Pacific Economic Cooperation (APEC) region to determine how the volume of trade, is determined by trade facilitation measures Wilson et al. (2003) established that improved airport and port efficiency positively affects intra-APEC trade. However, they found that regulatory barriers discourage trade. Limao and Venables (1999) used three different data sets to establish how transport depends on infrastructure and geography in SSA trade. Using a basic gravity model, their analysis of bilateral data confirms that a decline in quality of infrastructure results in a rise in cost of transport by 12 percent points and lowers trade volume by 28 percent.

Improved logistics resulting from improvements in physical infrastructure lowers trade costs and subsequently enhancing trade (Djankov et al., 2006; Behar and Manners, 2008 and Wilson et al., 2008). These findings support a study by Limao and Venables (2001) that employed a gravity model and 1990 data for 103 countries. Using a tobit model and fixed effects regression, they found that distribution of infrastructure from the 50^{th} percentile to 25^{th} percentile raises trade by 68 percent. In a related study, Fink et al. (2005) examined the link between communication costs and trade. Their findings revealed that lowering the cost of making phone calls between trading partners by 10 percent leads to a rise in bilateral trade volumes by 8 percent.

By controlling for transactions costs, free trade regime coordination, geographic, economic and political factors, De (2006) used a gravity model to investigate how trade and market access are influenced by infrastructure and transaction costs in Asia. A Gravity model was employed for 15 Asian countries using data covering the period 2000 and 2004. By employing a structural model, the study found that transaction costs and trade mobility infrastructure including rails, roads, telecommunications, and ports significantly explain trade variations in Asia. Similarly, using transport indexes for 43 countries covering the period 1996 to 2000, Clark et al. (2004) employed a gravity model to establish the determinants of maritime transport costs. To control for endogeneity, they employed instrumental variable technique and established that increasing the efficiency of ports efficiency from 25^{th} percentile to 75^{th} percentile from 25^{th} percentile lowers shipment costs by at least 12 percent hence increasing the volume of trade by 25 percent. Micco and Serebrisky (2004) used US import data for 1990-2001 to uncover the causes of air transport costs using reduced form approach. They found that improving air transport infrastructure and quality of regulation from 25^{th} to 75^{th} percentile lowers transport cost by 15 percent and air transport costs by 14 percent respectively. They further established that reduction in transport costs by 8 percent through open air agreements increases trade by approximately 10 percent.

Nordas and Piermartini (2004) used exports data for different sectors in 138 countries to estimate a gravity model and constructed an index for infrastructure quality based on transport and telecommunications infrastructure and time taken for border clearance. The study employed fixed effects and OLS methods to analyse the role of infrastructure quality on trade. The findings indicate that lack of quality infrastructure raises the likelihood of goods getting damaged during transportation and hence the transaction costs.

Different studies have explored the contribution of soft infrastructure to trade. For example, using institutional process and transparency as indicators of soft infrastructure, Abe and Wilson (2008) found that more gains in trade are realized with reduced corruption and improvement in transparency in APEC countries with low trade performance. By controlling for importer fixed effects and exporter remoteness for 146 countries, Freund and Rocha (2011) used Ease of Doing Business data and established that transit delays[24] have the largest negative economic effects on African exports. Bensassi et al. (2014) employed a gravity model augmented for logistics and transport infrastructure for 19 regions in Spain and 45 economies covering the period 2003 to 2007. Using a random effects model, their findings suggest that logistics is key in determining trade flows, specifically; quality and quantity of logistics facilities have positive effect on exports volumes. According to United States International Trade Commission (2009), higher production costs and losses were associated with shipment delays, overcrowding and congestion at the Kenyan ports which hampered firms' acquisition of imported production inputs in time.

There is no consensus with respect to the role of exporter and importer countries' infrastructure in enhancing bilateral exports. Grigoriou (2007) used random effects techniques to determine the role of transport infrastructure in promoting exports. By studying a panel of 167 countries between 1992 and 2004, the study established that improvement in both origin and destination country's infrastructures is important for exports. On the other hand, Longo and Sekkat (2004) investigated the contribution of infrastructure to Africa's trade and established that infrastructure in both origin and destination countries do not have uniform effects on bilateral trade particularly between Africa and developed countries.

Different studies support the idea that strong and high-quality institutions enhance trade. For example Beverelli et al. (2018) analysed how institutions affect international trade using data covering the period between 1996 and 2006 for a sample of 63 countries. They found a positive impact of institutions on exports and imports between poor and rich nations. In a different study, Francois and Manchin (2013) found that better quality institutions foster trade performance. Specifically the authors found that institutions of the exporting country lead to slightly stringer impact on exports compared to institutions of the importer country.

Institutional quality has also been proven as an important driver for sectoral bilateral trade in several countries around the world. Alvarez et al. (2018) used data for 186 countries for the

[24] Transit delays refer to time delays experienced in transporting goods from one destination to another.

period between 1996 and 2012 to analyse the extent to which quality of institutions drives both sectoral and aggregate bilateral trade. By employing gravity model, they found that better institutional quality improves trade for exporter and importer countries. Specifically, the study found that reinforcing institutions has a greater potential of improving trade in the agriculture sector compared to other sectors studied. The study further concluded that better institutional quality is associated with more trade since incidences of uncertainty are reduced. The findings support a previous study by Yu et al. (2015). Other studies supporting the positive contributions of quality institutions to trade include Jansen and Nordas (2004), Levchenko (2007) and Lin et al. (2018).

Some studies have found mixed results with respect to corruption and international trade. For example, in a study conducted using data drawn from the World Bank's World Business Environment Survey covering the period 1999 and 2002, de Jong and Bogmans (2010) concluded that corruption is known to impede international trade in general. However, the authors found that paying bribes to custom officials encourage imports particularly in countries with weak customs. Gil-Pareja et al. (2018) obtained similar results as de Jong and Bogmans (2010). They argue that on one hand, corruption may cause barriers to international trade by creating additional costs of conducting businesses internationally. On the other hand, corruption can enhance trade in economies with stringent guidelines, through a phenomenon referred as lubricating the wheels.

4.4 Literature Overview

Some of the past studies focused on a narrow range of infrastructure, for instance, Ansar et al. (2016) focused only on road and rail infrastructure projects, Kustepeli et al. (2012) focused on highway infrastructure. Shepherd and Wilson (2008) focused on transport infrastructure and ICT while Wilson et al. (2003) focused only on soft infrastructure, Limao and Venables (1999) focused on transport infrastructure, and Roller and Waverman (1996) focused on telecommunications infrastructure. This study comprehensively explored physical infrastructure indices (transport and communications) and soft infrastructure measures and their impact on the EAC's trade.

Previous studies have mostly paid attention on the effect of infrastructure on trade in general. This study goes further to establish how variations of both general exports and manufactured exports in the EAC are explained by infrastructure. In addition, the role institutional quality in determining intra-and inter-EAC trade is investigated in this analysis. This study therefore makes an important contribution to literature by establishing the role of physical and soft infrastructure measures in determining trade performance within EAC region and with other regional blocs in SSA. The study also incorporates the role of institutions in determining intra-and inter-EAC trade.

Table 4.3 presents a summary of previous empirical studies reviewed.

Table 4.3: Summary of Key Studies on Infrastructure and Trade

Authors	Data Type	Model/Methodology	Infrastructure Variable	Findings
Limao and Venables (2001)	A panel of 103 countries. Period: 1990	Gravity model capturing transport costs. Estimation: Fixed effects and Tobit	Index for kilometers of roads and railway and telephone lines	Infrastructure deterioration from median to 75th percentile lowers trade by 28percent
Micco and Serebrisky (2004)	US import data. Period: 1990-2001	Reduced form approach	Airport infrastructure	Lowering transport costs by 8 percent increases trade by approximately 10 percent.
Clark et al. (2004)	Bilateral trade data for 43 countries. Period: 1996-2000	Gravity model. Estimation: Instrumental variable	Transport indexes	Improvement in port efficiency drives up bilateral trade by 25 percent
Nordas and Piermartini (2004)	Sectoral exports for 138 countries. Period: Year 2000	Gravity model. Estimation: fixed effects and OLS	Infrastructure quality index based on road, port, airport and telecommunications	Low infrastructure quality reduces trade volume through high transaction costs
Wilson et al. (2005)	Manufactured exports for 75 countries. Period: 2000-2001	Gravity model. Estimation: OLS	Customs environment, port efficiency and service sector infrastructure	Improvement in port efficiency increase manufactured exports by US$

				107 billion
De (2006)	Total imports 15 Asian countries. Period: 2000-2004	Gravity model. Estimation: Fixed effects regression	Transport infrastructure: road, rail, port and air	Transport infrastructure significantly explain trade variations in Asia
Shepherd and Wilson (2009)	Total imports for 14 ASEAN countries. Period: 2000-2005	Gravity model. Estimation: OLS	Sea and air transport quality and ICT infrastructure	ICT and transport and infrastructures are the drivers of trade
Hernandez and Taningco (2010)	Total imports of industrial and petroleum products for 11 Asian countries	Gravity model. Estimation: Fixed effects regression	Port infrastructure and days to import	Quality of port infrastructure affects trade in industrial products
Portugal-Perez and Wilson (2012)	Exports data for 101 developing countries. Period: 2004-2007	Gravity model. Estimation: Heckman selection model	Hard and soft infrastructure indicators	Exports are mainly driven by physical infrastructure
Bensassi et al, (2014)	Exports data for 19 Spanish regions. Period: 2003-2007	Logistics and Transport augmented gravity model. Estimation: Random effects model	Logistics and transport infrastructure	Number and size of logistics increases exports
Ismail and Mahyideen (2015)	Agricultural and Manufactured exports for 10 Asian countries. Period: 2003-2013	Gravity model. Estimation: Random effects model	Transport and ICT infrastructure	Improved transport infrastructure significantly increase the volume of trade

4.5 Methodology

This section centres on the methodological aspects pertaining to the study. It discusses the empirical model upon which the study is based, variables and the sources of data. It further describes the methods that were employed in the analysis.

4.5.1 Theoretical Framework

Gravity Model

Gravity model determines the extent to which bilateral trade flows are affected by trade facilitation measures. The traditional gravity model was drawn from the Newton's Law of Gravity to explain the volume of trade among trading partners worldwide. Tinbergen (1962) first introduced the model. Anderson (1979) later modified the model to capture trade costs bases on the notion that each country produces a specific commodity, this uses the idea of product differentiation. Anderson and van Wincoop (2003) modified the model further to include multilateral trade resistance terms. The Law of Gravity is written as:

$$F = G\frac{M_1M_2}{D^2} \qquad (4.1)$$

Where *F*- refers to gravitational force between the two objects, $M_1$and M_2 refers to masses, *D*-refers to distance between the centres of $M_1$and M_2, and *G*- is a constant.

Gravity model of trade is represented as:

$$TR_{ij} = kY_i^{\beta}Y_j^{\gamma}D_{ij}^{\delta} \qquad (4.2)$$

Where TR_{ij}- is trade flow, from country *i* to country *j*;k −is a constant term;Y_i and Y_j- are GDPs of country *i* and *j*;D_{ij}-is distance between capital city *i* and *j*; β, γ and δ are coefficients. Hence equation (4.2) imply that trade between countries *i* and *j* is varies directly with the GDP of exporter and importer countries and inversely with the distance between them. Literature suggests geographical distance and country size as the main determinants of bilateral trade between economies.

Equation 4.2 can be modified to include MTR terms using importer and exporter fixed-effects as suggested (Anderson and van Wincoop, 2003). They argued that by not controlling for MTR between countries, the gravity model would suffer from variable omission bias. The new equation is given as:

$$TR_{ij} = kY_i^{\beta} Y_j^{\gamma} D_{ij}^{\delta} \varepsilon^{\theta_i \sigma_i + \theta_j \sigma_j} \quad (4.3)$$

Where σ_i and σ_j are dummies for exporter and importer respectively and ε −is error term.

Modification of the gravity model can further be done to capture other key factors determining trade costs and volume such as infrastructure and other trade facilitation measures. Gravity model, hence, provides an important link between trade flows and related barriers.

A linear version of Equation 4.2 is given as:

$$Ln\left(TR_{ij}\right) = \alpha + \beta \ln(Y_i) + \gamma \ln\left(Y_j\right) + \delta \ln\left(D_{ij)}\right) + \varepsilon_{i,j} \quad (4.4)$$

Equation (4.4) is a baseline gravity model. It is further augmented to include variables such as institutional variables, infrastructure, FDI, language, inflation, exchange rates, non-tariff barriers e.t.c. consequently, the model is modified to capture these variables to determine how they effect trade.

Gravity model, however, has some limitations; the model centres on bilateral trade and only describes changes in trade volume. Further, based on the assumptions of the model, it cannot explain substitutions between trade flows. The basic gravity model cannot solve the fact that trade costs of the third party can influence trade between the two partners (Bergeijk and Brakman, 2010). Therefore, one of the possible consequences associated with the weaknesses of the gravity model is that the model may suffer from variable omission bias. However, this study employed panel estimation which allows for control of omitted variables using country-pair specific effects.

4.5.3 Empirical Model

The third objective determines the impact of infrastructure stock on EAC's trade. Following literature on trade, this study used an augmented gravity model. It is known to be highly reliable model in analysing the differences in cross-border trade (De, 2006). A log-linearized gravity equation is given as:

$$\ln EX_{i,t} = \gamma_o + \gamma_1 \ln GDP_{i,t} + \gamma_2 \ln GDP_{j,t} + \gamma_3 D_{i,j} + \gamma_4 \ln INFR_{i,t} + \gamma_5 lnINFR_{j,t} + \gamma_6 lnFDI_{i,t} + \gamma_7 INF_{i,t} + \gamma_8 ER_{i,t} + \gamma_9 CI_{i,t} + \gamma_{10} lang_{i,j} + \gamma_{11} lnPOP_{i,t} + \gamma_{12} lnPOP_{j,t} + \gamma_{13} FTA + \gamma_{14} REGQ_{i,t} + \gamma_{15} MM_{i,j} + \gamma_{16} WTO_j + v_t + u_{ij} + \varepsilon_{i,t} \quad (4.5)$$

Where

$EX_{i,t}$-Total exports (manufactured exports) from i^{th} Partner State (i^{th} region) to the j^{th} Partner State, the trading destination (importing country) at a given time, *t;* $GDP_{i,t}$-Exporter's real GDP in year *t*; $GDP_{j,t}$- Importer's real GDP at time *t*; $D_{i,t}$-Distance between capitals of country i and *j*; $INFR_{i,t}$-Exporter's infrastructure in year *t*; $INFR_{j,t}$-Importer's infrastructure in year *t*; $FDI_{i,t}$- Foreign direct investment; $INF_{i,t}$- Inflation; $ER_{i,t}$- Exchange rate for country *i's* currency against the US dollar in year *t*; $CI_{i,t}$- Corruption index; $lang_{i,t}$-dummy for official language, where 1= similar language by trading partners *i* and j, 0 –otherwise, $POP_{i,t} -$ Country *i's* population at time t in EAC and $POP_{j,t}$ is trading partner's population, *FTA*- Free trade agreements, *REGQ*-Regulatory quality, *MM*-Multiple membership, *WTO*-World Trade Organization (WTO) Agreements, v_t −time fixed effects, u_{ij} −bilateral random effects and $\varepsilon_{i,t}$– is the error term. From the model, time fixed and bilateral random effects are useful in controlling for unobserved heterogeneity.

4.5.4 Variables Definitions and Expected Signs

The expected signs of $\gamma_1, \gamma_2, \gamma_4, \gamma_5, \gamma_6, \gamma_8$, γ_9, γ_{10}, γ_{13} and γ_{14} are positive while the expected signs of γ_3 and γ_7 are negative and the expected signs of γ_{11}, γ_{12} and γ_{15} are indeterminate. Distance and the dummy variables are time invariant; fixed effects model controls for the effect of variables do not vary with time, while random effects model allows for the effects of such variables. Since variables were transformed to logs, the coefficients are interpreted as elasticities such that it is possible to get a percentage contribution of a given infrastructure and other regressors in the model on exports of manufactured goods and other goods in general.

Bilateral Export: Bilateral export in this study is the dependent variable in the empirical model. The volume of trade between two countries *i* and *j* is given by the bilateral exports. This refers to exports from i^{th} Partner State to j^{th} Partner State. In intra-EAC trade, each exporting country has 4 trading partners (importers). The exports of origin country *i* should be the imports of the destination country *j*. Therefore, no significant disparities should exist on the use of exports or imports as the dependent variable since a country *i*'s exports are country *j*'s imports. However, in some cases, discrepancies could exist between the exports and imports of any two trading partners, such that country *i*'s exports do not coincide with country *j*'s imports, this, according to United Nations[25], can be due to the timing of the reporting or exclusion or inclusion of certain goods. Nevertheless, Head et al. (2010) argue that imports are sometimes more reliable than exports in capturing bilateral trade volume[26].

Real GDP: GDP is the total value of an economy's domestic production in a year. It is theoretically expected that as a country grows, more output is produced, and the volume of trade should also go up as well. Therefore, it is expected that real GDP of the exporting country and trade volume should have a positive relationship. Similarly, the importer's GDP is also predicted to have a direct relationship with exports since more income would increase the demand for imports.

Population: It is the total number of people living in a country. High population can imply abundant supply of cheap labour, both skilled and unskilled hence increased production and trade. However, a large domestic population can offer a big domestic market hence less international trade. Turkson (2012) found evidence of a negative association between population size and bilateral trade. Hence, the role of population in explaining bilateral trade is indeterminate.

Distance: The geographical distance variable is used to capture transport costs in the model. It is given by the weighted distance[27] in kilometers between the capital cities of two trading partners as most economic activities such as trade tend occurs in these cities. The distance between two countries is given the distance between two capitals trading partners. Distance is expected to negatively impact on trade since longer distance increases transaction costs thereby discouraging trade.

Transport Infrastructure: Infrastructure measured by the length of paved roads, railway and number of airport facilities is used to capture the stock of public infrastructure in transport sector. It is expected to influence trade positively.

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[25]See https://comtrade.un.org/db/help/uReadMeFirst.aspx, for details.
[26]Since imports must be cleared by custom authorities and subjected to custom duties, they are often tracked more by governments
[27] Head and Mayer (2002) developed a formula used by CEPII data base to calculate the weighted distance between two trading partners.

ICT Infrastructure: It refers to economic infrastructure related to communications technology. A well-developed ICT infrastructure is expected to lower communication costs and positively contribute to bilateral exports. The expected sign between ICT infrastructure and bilateral exports in EAC is expected to be positive.

Language: Official language dummy captures information costs between trading partners. The study uses two language dummies, the first for two countries sharing an official language and the second is if at least 9 percent of the population in two nations speaks a given ethnic language. Ease of communication by sharing a common language should boost trade because of easier transactions and increased transparency (Fidrmuc and Fidrmuc, 2016). Therefore, trade between two countries could be low if they do not have a common language. The expected sign is positive for two countries with a common language.

Common Border: This is a dummy for contiguity or adjacency. The study includes a dummy for common border in the model. This is because trade should be easier if two trading partners have a common border. Volume of trade is expected to be high if two countries have the same border hence a positive relationship.

Free Trade Area: This dummy captures effects of regional integration. Regional trade agreements reduce bureaucracies and other costs associated with trade between countries. It is anticipated that the presence of regional trade agreements increases trade between countries and therefore the expected sign between free trade agreements and bilateral exports in EAC is positive.

Foreign Direct Investments: It refers to investment to the domestic economy from a foreign country. High investments inflows to the exporting country are likely to expand production opportunities, which are likely to promote exports. FDIs are therefore, expected to enhance trade.

Inflation Rate: It refers to annual percentage change in consumer price index. A high inflation level in the exporting country signifies higher prices and discourages exports. Therefore, inflation is expected to be negatively related with exports.

Exchange rate: Exchange rate depreciation makes exports cheaper and therefore, expected to contribute positively to exports while exchange rate appreciation makes exports more expensive and therefore, discouraging exports. The expected sign is positive for depreciation of an exporter's currency relative to the currency of the importing country and negative for appreciation. The overall expected sign is therefore indeterminate.

Recent literature on trade using gravity models emphasize that good institutions promote trade (Francois and Manchin, 2013). Some authors such as Levchenko (2007) argue that comparative advantage can often arise from differences in institutional quality and that trade is explained by the nature of institutions in various countries. Studies by Anderson and Marcouiller (2002) have also linked positively bilateral trade and quality of institutions. Quality institutions are therefore, expected to contribute positively to trade volumes in EAC. The study used regulatory quality and control of corruption index as institutional variables.

Regulatory Quality: It is an index which captures a government's ability to come up and employ policies that enhance private sector activities. High regulatory quality is likely to encourage trade; therefore, exports and regulatory quality should have a direct relationship.

Control of Corruption Index: It refers to accountability in the use of resources in the public sector or the degree to which public power is used for individual benefits. High corruption level in a country can increase trade costs, lowering the trade volume. Control of corruption lowers the burden associated with corrupt and non-transparent procedures such as irregular payments and bribes paid at border posts (Abe and Wilson, 2008). Therefore, it is expected that control of corruption index and volume of trade in EAC have a positive relationship.

WTO Agreements- This is a dummy which captures trade agreements under WTO. These trade agreements replaced the General Agreements on Tariffs and Trade (GATT) in 1995. The WTO trade agreements are meant to reduce barriers to international trade among the member countries through a legal framework. Therefore, more trade is expected among countries that are signatories of the WTO agreements. Larch et al. (2019) found evidence of increased trade among the countries that joined GATT/WTO, contrary to the findings by Rose (2004) and Roy (2011) who found no significant effect of WTO on trade.

Multiple Membership- This is a dummy which captures countries that have memberships in more than one REC in this study. For example, Tanzania belongs is Partner State of EAC and also a Member State of SADC. The effect of overlapping membership in regional trade remains ambiguous. For example Aryeetey and Oduro (1996) argue that overlapping membership impedes regional integration through duplication of effort while Afesorgbor and van Bergeijk (2011) found a positive impact of multiple membership on bilateral trade in ECOWAS.

4.5.5 Measurement and Sources of Data

The study covers the period 1990 to 2019. Such a relatively long period is preferred to capture well, the heterogeneity of trade flows and trade facilitation measures in EAC. Table 4.4 presents the variables used in the gravity model, their measurements and sources of data.

Table 4.4: Variables Measurements and Data Sources

Variable	Measurement	Data Source
Bilateral Exports	Gross Exports in US dollars / Manufactured exports from country *i* to *j* from 1990-2017, in logs	WITS (World Integrated Trade Solutions), (COMTRADE) database
Real GDP (Economic Size)	Measured at constant 2010 US$	WB, WDI (2020) Data Base
Distance	Weighted distance in kilometers	CEPII Data Base
Transport Infrastructure	An index constructed based on kilometers of roads and railway (Refer to Tables F1-F3 in Appendix F for PCA methodology on transport infrastructure index).	National Bureau of statistics, AfDB data base and WDI
ICT Infrastructure	Index constructed based on number of mobile phones, main telephones and internet subscriptions (see Tables F4-F6 in Appendix F for details).	WDI and AfDB data base
Infrastructure Quality	A value of 0 = extremely underdeveloped and 7 = extensive and efficient by international standards. This study also uses document to export, time and cost to export as proxies of infrastructure quality.	WEF, Ease of doing Business on quality of infrastructure. WDI, WB (2020) Data Base.

FDI	FDI inflows (net) as a percentage of GDP.	WB, WDI (2020) Data Base
Inflation Rate	Consumer prices (annual percent)	WB, WDI (2020) Data Base
Real Effective Exchange Rate	A country's currency relative a weighted average of other currencies. It is based on the CPI	IMF, Regional Economic Outlook
Corruption Index	A rating of (1=low to 6=high) It ranges from -2.5 = weak and 2.5 = strong	WB, WGI (2020) Data Base
Language	Using a dummy, where 1 = common language, and 0 = otherwise	CEPII Data Base
Population	Mid-year estimates of the residents of a country, in millions	WB, WDI (2020) Data Base
Common Border Dummy	A value 1= two countries have common land border, 0 otherwise	CEPII Data Base
FTA	A value 1 = if country *i* and *j* have a common trade agreement i.e. belong to EAC, 0 otherwise. This value would be 0 for all EAC partner states between 1990 and 1999 when EAC was inactive. EAC became active in 2000 for Kenya, Tanzania and Uganda and therefore, a value of 1 between 2000 and 2019. Burundi and Rwanda joined EAC in 2007, therefore, would take a value of 1 between 2007 and 2019.	Author
Regulatory Quality	Aggregate index where a value of -2.5 = low regulatory quality and 2.5 = high regulatory quality	WGI of the World Bank
WTO	A value 1 = if country *i* and *j* are	CEPII Data Base

	signatories to WTO trade agreements, 0 otherwise.	
Multiple Membership	A dummy with a value 1= if country *i* in EAC is also a member of another regional block in SSA, 0 otherwise	Author
Land Area	Total land area of a country in square kilometers	CEPII Data Base

4.5.6 Key Econometric Issues

4.5.6.1 Test for Cross-Sectional Dependence and Stationarity

CD is common in macro panels and may result in contemporaneous correlation[28]. It is also important to test for stationarity of variables before estimation to evade spurious regression. Therefore, the study used IPS, LLC, Breitung, Fisher, HT and Hadri LM tests for unit roots.[29]

4.5.6.2 Unobserved Heterogeneity

The presence of unobserved heterogeneity in a gravity model controlled for by introducing bilateral random- and time-fixed effects. Another approach is to run a regression using a Mundlak approach, a technique which involves controlling for heterogeneity that may have a correlation with the time invariant component of the idiosyncratic term.

4.5.7 Estimation Methodology

After a series of reviews and reformulations, Gravity is widely accepted in explaining trade between nations and economic regions. It is essential to employ appropriate methodology in the estimation of Gravity model. The least squares technique involves a log-transformed representation of the gravity model and becomes valid only under the assumption of homoscedasticity. This assumption, according to Santos Silva and Tenreyro (2006) does not hold in a log-linear formulation of the gravity model and therefore, the error terms are heteroscedastic. The existence of heteroscedasticity in a model results in inefficient and inconsistent estimates.

[28]Refer to section 2.5.5.1 of this document for a detailed explanation of the problem of CD.
[29] For properties and detailed analysis of the unit root tests, refer to Section 2.5.5.6. of the document.

Another challenge thatcomes with the least squares estimation of the gravity model is when there is no bilateral trade between two economies (zero trade). According to Frankel (1997), the zero values imply lack of trade between two trading partners in a particular time period. They can also either be attributed to rounding errors or errors where some missing observations are documented as zeros.

The current trade economists such as Bensassi et al, (2014) and Ismail and Mahyideen (2015) therefore, shifted focus towards dealing with the problem resulting from log-formulation and the presence of many zeros in bilateral trade flows. Methodologies such as probit regression, truncated regression and Poisson models have been applied to handle such problems. This study, therefore, uses random effects and Poisson Pseudo Maximum Likelihood (PPML) estimation methods to determine the link between infrastructure and trade.

4.5.7.1 Random Effects Estimation

One advantage of using panel data is the ability to control for unobserved fixed effects. The gravity model has variables that do not vary with time such as distance and language. Estimation of such as a model using a fixed-effects model eliminates the effects of variables that do not vary with time. A random-effects model is suitable since it allows the model to include time invariant variables included in the model.

A one-way error components model takes the form:

$$Y_{it} = \delta + \beta X_{it} + u_{it}; \qquad i = 1,2,\dots,N; t = 1,2,\dots,T \qquad (4.6)$$

$$u_{it} = u_i + v_{it} \qquad (4.7)$$

Where Y_{it} refers to the dependent variable, bilateral exports and X_{it} refers to the set of explanatory variables. A fixed effects model assumes that u_i is fixed. A random effects model assumes that u_i is random such that individual error components are uncorrelated with each other and not autocorrelated across time series and cross-section units (Baltagi, 2005). The assumption makes the random effects estimates to be consistent and effective as shown in Equation 4.8.

$$v_{it} - iid(0, \theta_v^2); \qquad u_i - iid(0, \theta_u^2)$$

$$Cov(v_{it}, u_{it}) = 0 \quad Cov(v_{it}, X_{it}) = 0 \quad Cov(X_{it}, u_i) = 0 \qquad (4.8)$$

The sample countries are assumed to have same mean value for δ and variations of each country are captured by u_i. The random effects model estimated takes the form:

$$\ln EX_{i,t} = \gamma_o + \gamma_1 \ln GDP_{i,t} + \gamma_2 \ln GDP_{j,t} + \gamma_3 D_{i,j} + \gamma_4 \ln INFR_{i,t} + \gamma_5 lnINFR_{j,t} + \gamma_6 lnFDI_{i,t} + \gamma_7 INF_{i,t} + \gamma_8 ER_{i,t} + \gamma_9 CI_{i,t} + \gamma_{10} lang_{i,t} + \gamma_{11} lnPOP_{i,t} + \gamma_{12} lnPOP_{j,t} + \gamma_{13} FTA + \gamma_{14} REGQ_{i,t} + \gamma_{15} MM_{i,j} + \gamma_{16} WTO_j + u_{i,t} \quad (4.9)$$

4.5.7.2 Poisson Pseudo Maximum Likelihood Estimation

If there are many zeros[30] in bilateral trade, PPML performs well (Silva and Tenreyro, 2009). PPML assumes conditional variance as proportional to conditional mean.

Let y_{it} and x_{it} be the dependent and independent variables respectively and $\beta$is the parameter to be estimated. Assuming conditional expectation is proportional to the moment *m*, *x* and β and takes the form exp $(x_t\beta)$. The coefficients are estimated by maximizing a log-likelihood function given by:

$$l_i(\beta) = \sum_{t=1}^{T} (y_{it} \log[m(x_{it}, \beta)] - m(x_{it} - \beta)) \quad (4.10)$$

PPML estimator has the ability to produce consistent estimates of the non-linear gravity model. The fact that a PPML estimator is used in estimation does not imply that the data used must follow a Poisson distribution. A multiplicative form of gravity model takes the form:

$$E(EX_{i,j}|X_j) = \gamma_0 GDP_i^{\gamma_1} GDP_j^{\gamma_2} D_i^{\gamma_3} INFR_i^{\gamma_4} INFR_j^{\gamma_5} FDI_i^{\gamma_6} INF_i^{\gamma_7} ER_i^{\gamma_8} CI_i^{\gamma_9} POP_i^{\gamma_{10}} POP_j^{\gamma_{11}} FTA^{\gamma_{12}} REGQ_i^{\gamma_{13}} INST_j^{\gamma_{14}} DM_{i,j}^{\gamma_k} \quad (4.11)$$

Where

$EX_{i,j}$ −Bilateral exports from country *i* to *j*. This is modeled for all exporting countries in the regional bloc (EAC). X_j −are the regressors in the gravity model and *DM-* is a vector of dummy variables. Equation (4.11) is then log-linearized for estimation.

[30]Zeros in the gravity model implies no bilateral trade between trade partners. In such a case exports or imports are recorded as zeros.

PPML model generates estimates of $EX_{i,j}$ instead of $lnEX_{i,j}$ hence the problem of underestimation of large trade flows and total trade volume is avoided (Burger et al., 2009). Furthermore, the estimation of PPML using maximum likelihood technique makes the estimates to be adapted to the actual data, an indication that the sum of the predicted values is virtually identical to the sum of the input values.

Another advantage of PPML is that when there is heteroscedasticity, the estimates are still efficient particularly when a large sample is used. In addition, the multiplicative form of PPML gives a standard way to handle the zero-captured trade flows.

With fixed effects, PPML is still reliable. Like in simple OLS, fixed effects can be applied in a model as dummy variables. This is important when employing a gravity model which sometimes include exporter and importer fixed effects[31].

Unlike OLS model which drops zero trade values in a model, PPML has additional property of including zero trade observations in the model. A sample selection bias may occur when the zero observations are dropped from a model.

[31]"Alternative Gravity Model Estimators". Accessed at: https://www.unescap.org/sites/default/files/6%20%204.%20Alternative%20Gravity%20Model%20Estimators_0.pdf

4.6 Results and Discussion

This section presents the analysis of the role of infrastructure in determining intra-EAC trade using gravity model. Subsection 1 describes the variables in the model in the form of descriptive statistics; in subsection 2, correlation analysis was done to understand the nature of relationship between the explanatory variables. Subsection 3 discusses the econometric tests conducted in the study. Subsection 4 discusses regression results between infrastructure variables and trade in EAC. Robustness checks for the regression on transport and ICT infrastructure are presented in subsection 5 while regression on soft-infrastructure and trade is presented in section 6. Subsection 7 presents the findings on transport and ICT infrastructures and manufactured exports in EAC. Regression results on inter-EAC trade are presented in subsection 8.

4.6.1 Descriptive Statistics

Table 4.5 gives summary statistics for entire EAC countries over the period 1990 and 2019.

Table 4.5: Summary Statistics for EAC

Variable	Minimum	Maxi.	Mean	Std. Dev	Skewness	Obs.
Exports (US$ Million)	1.41	793.89	81.04	135.78	2.55	600
GDP *i* (US$ Million)	785	87,900	16,900	18,700	1.60	600
GDP *j* (US$ Million)	785	87,900	16,900	18,700	1.60	600
Weighted distance (Km)	162.18	950.22	684.89	244.84	-0.77	600
Population *i* (Million)	6.01	56.30	25.7	15.50	0.12	600
Population *j* (Million)	6.01	56.30	25.7	15.50	0.12	600
REER	57.11	2,263.78	871.50	611.92	0.44	600
FDI (US$) Million	100	2,090.0	402.0	496.00	1.36	600
Contiguity	0	1	0.70	0.46	-0.87	600
Common Lang. Official	0	1	0.70	0.46	-0.87	600
Common Lang. Ethnicity	0	1	0.50	0.50	0	600
Colonial Ties	0	1	0.40	0.49	0.41	600
Inflation	-2.81	31.11	8.24	5.82	1.32	600
Transport Infrastructure *i*	-1.07	3.08	0.08	1.05	0.89	600
Transport Infrastructure *j*	-1.07	3.08	0.08	1.05	0.89	600
ICT Infrastructure *i*	-0.92	2.10	-0.08	1.00	0.67	600
ICT Infrastructure *j*	-0.92	2.10	-0.08	1.00	0.67	600
Corruption Index	-1.45	0.76	-0.72	0.47	1.59	600
Free Trade Area	0	1	0.61	0.49	-0.46	600

Note: *The variables common lang. official and common lang. ethnicity refers to common official language and ethnic language between two countries' population respectively. The descriptive summary statistics were based on 600 observations, from 1990-2019.*

The bilateral exports within the EAC region averaged US$ 81 million between the year 1990 and 2019 (Table 4.5). The largest exporter in EAC region is Kenya with an average export to other Partner States of US$ 203 million, more than twice the EAC average, followed by Uganda with US$ 89 million between 1990 and 2019. Kenya's exports share in EAC constitutes 50 percent, followed by Uganda and Tanzania at 22 and 20 percent respectively. The smallest trade shares in EAC are 7 and 1 percent for Rwanda and Burundi have respectively. Kenya has relatively well-developed industrial sector as compared to her EAC counterparts and therefore exporting more. Tanzania and Rwanda come third and fourth respectively with average exports value of US$ 82 and US$ 28 million respectively. Burundi is the smallest exporter with average export value of US$ 4 million during the same period. The standard deviation of exports is US$ 136 million, showing large disparity and volatility in exports in EAC.

GDP averaged US$ 16,900 million for the period under study. Kenya is the top economy in EAC and had an average GDP of US$ 35,700 million for the period under study. Tanzania comes second with an average GDP of US$ 27,800 million, Uganda and Rwanda come third and fourth with average GDP of US$ 14,800 million and US$ 4,650 million respectively. Burundi is the smallest economy in EAC with an average GDP of US$ 1,700million. Economies that are relatively larger with respect to income should export more.

The average population in EAC was 25.7 million. Tanzania had the highest average population of 41.6 million with a maximum of 56.3 million people during the study period. The second is Kenya with a mean population of 39.2 million and a maximum 48.5 million, other countries Uganda, Rwanda and Burundi have a mean population of 30.0, 9.4 and 8.11 million and with a maximum of 42.7, 12.3 and 11.2 million respectively. A large population is an important source of cheap labour for industrial and agricultural production and ready market for the products.

Transport infrastructure is crucial for international trade by lowering transport costs, hence increasing export volumes. The EAC Partner States still have very low level of infrastructure development with an average infrastructure stock index of 0.08, with a minimum stock of -1.07 and a maximum of 3.08 between 1990 and 2019. Kenya being the best performing with an average transport infrastructure index of 1.37 and a high of 3.08. The rest of the countries Tanzania, Uganda, Burundi and Rwanda have an average transport infrastructure index of 0.66, -0.31, -0.79 and -0.86 respectively.

In terms of ICT infrastructure, the EAC still have low levels of ICT infrastructure with an average infrastructure stock index of -0.08, with a minimum of -0.92 and a maximum of 2.10. Kenya still ranks top in terms of ICT, with an average of 0.43 and a maximum of 1.95. Tanzania, Rwanda, Uganda and Burundi have average ICT infrastructure index of 0.18, 0.10, 0.05 and -0.46 respectively. ICT infrastructure is very crucial for trade since it boosts efficiency in the borders thereby promoting exports.

In terms of control of corruption, EAC had an average control of corruption index of -0.72, with a minimum of -1.45 and a maximum of 0.76. The country with the best control of corruption ratings was Rwanda with an average of -0.04. The ability of a country to control corruption is an indicator of good governance and is likely to make the public sector more efficient. The rest of the countries, Tanzania, Uganda, Kenya and Burundi had averages of -0.62, -0.90, -1.0 and -1.06 respectively. This implies that corruption is still a serious problem in EAC which could limit exports through additional costs to trade.

The average weighted distance among the EAC Partner States is 684.89 kilometers, with a minimum of 162.18 kilometers and a maximum 950.22 kilometers. Tanzania has the longest distance to other EAC members with an average of 857.70 kilometers and a maximum of 950.22 kilometers. Kenya comes second with an average distance of 743.38 kilometers to other EAC members. Uganda, Burundi and Rwanda have average of 627.75, 622.12 and 582.48 kilometers respectively.

Tables F7 to F11 in appendix F present the summary statistics of key variables in individual models for EAC Partner States. This covers the period 1990-2019.

The descriptive statistics for Burundi are presented in Table F7. Exports from Burundi to other EAC counterparts averaged US$ 3.83 million between 1990 and 2019. The wide range and large standard deviation of US$ 4.89 million implies that Burundian exports are highly volatile. The country had an average GDP of US$ of 1,700 million, the lowest in EAC. Other EAC counterparts had an average GDP of US$ 20,700 million, with a minimum of US$ 1,380 million and a maximum of 87,900 million, higher than that of Burundi. Burundian population averaged 8.11 million over the period under coverage. Inflation averaged 11.50

percent between 1990 and 2019. Real effective exchange rate averaged 1,118.01 with a standard deviation of 426.34, implying that the Burundian currency is highly volatile.

In terms of transport infrastructure, Burundi has a low level of transport infrastructure development. The average transport infrastructure index[32] for Burundi was -0.69, which is very low implying that the country needs to invest more in transport infrastructure. The country had average ICT infrastructure index[33] of -0.46, with a maximum and minimum of 0.34 and -0.89 respectively. Burundi's average corruption index for the study period is -1.06, with a low of -1.45 and a high of -0.68 implying that the country's governance is still weak though improving.

Table F8 refers to statistics relating Kenya. Kenya's exports to the EAC Partner States averaged US$ 203.04 million between 1990 and 2019. The standard deviation for exports is 187.12 million. The large standard deviation implies that Kenya's exports are volatile. The average GDP was US$ 35,700 million, which was larger than the average of US$ 12,200 million for the other EAC counter parts. The average weighted distance from Kenya to her EAC counter parts is 743.38 kilometers. Population has been increasing steadily, from a low of 28.19 million to a high of 48.46 million. The transport infrastructure index averaged 1.73, with a minimum of 1.37 and a maximum of 3.08, implying that Kenya's transport infrastructure highly improved over the period under consideration. However, in terms of control of corruption, the country attained an average control of corruption index of -1.00, which is relatively weak.

Table F9 presents the summary statistics for Rwanda's in the gravity model. Rwanda exported goods worth US$ 27.7 million to EAC Partner States between 1990 and 2019. The exports, however, have a large standard deviation of US$ 44.6 million, an indication of volatility in trade. The country's GDP and weighted distance to other EAC countries averaged US$ 4,650 million and 582.48 kilometers respectively. Rwanda's population is relatively small and averaged 9.4 million for the study period. The country's transport infrastructure development is still low and averaged only -0.86 and therefore, more investment is required in roads and railway to boost the infrastructure stock.

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[32]An index constructed using PCA analysis, it includes road and railway infrastructure and ranges from -5 (low) and 5 (high). See Tables F1 to F3 in appendix F for detailed PCA methodology on construction of transport infrastructure stock index for the EAC member countries.

[33]See Tables F4 to F6 in appendix F for the methodology used in construction of ICT infrastructure index for all the EAC member countries.

Table F10 refers to summary statistics relating to Tanzania's gravity model. Exports from Tanzania to other EAC Partner States averaged US$ 82.04 million and with a standard deviation of US$ 134.00 million. The large standard deviation indicates instability in Tanzania's export earnings. The GDP, weighted distance and population averaged US$ 27,800 million, 857.7 kilometers and 41.06 million respectively. Transport infrastructure development index averaged 0.67 and improved from a minimum of 0.05 to a maximum of 1.87. Control of corruption index averaged -0.62 which is still low implying weak governance structures.

Uganda's statistics are highlighted in Table F11 for gravity model variables. Uganda's exports to other EAC members averaged US$ 88.62 million with a standard deviation of US$ 115.67 million for the period under consideration. The GDP, weighted distance and population averaged US$ 14,800 million, 627.75 kilometers and 30.03 million respectively. Transport infrastructure development index averaged -0.31 with a maximum of 0.05, indicating poor transport infrastructure in the country. Control of corruption is still low for Uganda, with an average index of -0.90 and a maximum of -0.72.

4.6.2 Correlation Analysis

The correlation results indicate the level of interdependence between the variables. The analysis is also important in detecting any possibility for multicollinearity among the explanatory variables in the model. The correlation results are presented in Table 4.6.

The results show that both GDPs of the exporter and importer countries are positively statistically significant correlation with exports. This implies that a country is likely to export and import more due to expansion of the economy and increase in income. This is statistically significant for all the EAC Partner States.

Distance is negatively correlated with exports in EAC. This is statistically significant for all the EAC Partner States. From theory, longer distance lowers the volume of trade due to associated increased cost of transport.

Population is another important determinant of exports in EAC, exports and population are positively correlated. High population is a source of cheap labour hence increasing production and exports. However, high population could also imply a large market size, resulting in higher exports.

Table 4.6: Correlation Analysis, EAC

	LEXP	LGDPi	LGDPj	LDIST	LPOPi	LPOPj	INF	LRER	LFDI	INFRi	INFRj	ICTi	ICTj
LEXP	1												
LGDPi	0.78**	1											
LGDPj	0.28**	0.04	1										
LDIST	-0.15*	0.25**	0.25**	1									
LPOPi	0.71**	0.89**	-0.07	0.36**	1								
LPOPj	0.14**	-0.07	0.90**	0.36**	-0.17*	1							
INF	-0.2**	-0.1*	-0.1	0.01	-0.1	-0.2	1						
RER	0.4**	0.08	0.27**	0.02	0.12**	0.13**	-0.15*	1					
LFDI	0.66**	0.80**	0.02	0.22**	0.75**	-0.1	-0.3**	0.1*	1				
INFRi	0.61**	0.72**	-0.1	0.32**	0.8**	-0.1*	0.02	-0.6**	0.5**	1			
INFRj	0.18**	-0.1	0.8**	0.32**	-0.1*	0.8**	-0.1	0.2*	0.02	0.3*	1		
ICTi	0.54**	0.64**	0.37**	0.07	0.4**	0.2**	-0.1	0.1	0.5**	0.5**	0.2**	1	
ICTj	0.39**	0.37**	0.65**	0.07	0.2**	0.4**	-0.1	0.3**	0.3**	0.2**	0.5**	0.8**	1

*Note: L-Indicates the variables in logs, ** and * indicate significance at 1 percent level and at the 5 percent level respectively.*

Transport infrastructure and exports in EAC are positively correlated. This is an indication that a well-developed infrastructure increases exports due to reduced distance between trading partners. This results in reduced transport costs which increases trade between any two trading partners.

ICT infrastructure has a positive correlation with bilateral exports in EAC. A well-developed ICT infrastructure increases efficiency and lowers general costs incurred during trade, which results in increased exports.

4.6.3 Econometric Tests

This section discusses the pre-estimation diagnostic tests such as panel unit roots, and Hausman tests that were conducted in this study.

4.6.3.1 Panel Unit Roots

Time series variables were subjected to unit root tests to determine their properties in terms of stationarity. LLC and IPS tests for unit roots were used (Table 4.7).

Table 4.7: Panel Unit Root Test for Variables in Gravity Model

	Order of Integration					
	Burundi	**Kenya**	**Rwanda**	**Tanzania**	**Uganda**	**EAC**
LXij	I (0)	I (0)	I (0)	I (1)	I (1)	I (0)
LGDPi	I (1)	I (1)	I (1)	I (1)	I (1)	I (1)
LGDPj	I (1)	I (1)	I (1)	I (1)	I (1)	I (1)
LPOPi	I (1)	I (1)	I (0)	I (1)	I (1)	I (1)
LPOPj	I (1)	I (1)	I (1)	I (1)	I (1)	I (1)
LRER	I (0)	I (1)	I (0)	I (1)	I (1)	I (1)
LFDI	I (0)	I (1)	I (1)	I (0)	I (1)	I (1)
INF	I (0)	I (0)	I (0)	I (0)	I (0)	I (0)
INFRA i	I (1)	I (1)	I (1)	I (1)	I (1)	I (1)
INFRA j	I (1)	I (1)	I (1)	I (1)	I (1)	I (1)
COR	I (0)	I (0)	I (1)	I (1)	I (1)	I (1)

From the results, I (0) variables were stationary at level while the I (1) variables were stationary after first difference. Therefore, a mixture of I (0) and I (1) variables existed in the gravity model for individual countries.

4.6.3.2 Hausman Test

The gravity model employed in this study has different time invariant variables for example distance, language, contiguity and common colonizer. Hence the ideal estimation technique should be one that considers time invariant variables such as a random effects model. A random-effects model allows the invariant to be included in a regression model, contrary to the fixed effects model which gets rid of the effects of the time invariant variables. Hausman test was conducted to ascertain the appropriate methodology. The results confirm random effects model as appropriate (See Table F12 in the appendix F).

4.6.4 Regression Analysis of Transport and ICT Infrastructure and Intra-EAC Trade

The augmented gravity model Equation (4.5) was estimated for EAC Partner States. Bilateral exports data covering the period 1990-2019 was used as the dependent variable. Indexes for ICT and transport infrastructures stock were constructed and used in this analysis; the results are illustrated in Table 4.8.

Table 4.8: Regression Analysis of Transport and ICT Infrastructure and Trade

Dependent Variable: Log of Exports			**Method: Random Effects**	
Variable	**Coefficient**	**Std. Error**	**z**	**P|z|**
$dLog\ of$ GDP$_i$	1.2547**	0.5585	2.25	0.025
$dLog\ of$ GDP$_j$	1.1233**	0.5598	2.01	0.045
$dLog\ of$ POP$_i$	24.34***	6.0965	3.99	0.000
$dLog\ of$ POP$_j$	11.6275**	5.8644	1.98	0.047
$dTRANS.INFRA_i$	0.7368***	0.1419	5.19	0.000
$dTRANS.INFRA_j$	0.1185	0.3168	0.37	0.708
$dICT\ INFRA_i$	1.0284***	0.3656	2.81	0.005
$dICT\ INFRA_j$	0.8064**	0.3556	2.27	0.023
RER	0.5657***	0.1279	4.45	0.000
$dLog\ of\ FDI$	0.0593*	0.0337	1.76	0.078
$Log\ of\ DIST$	-2.1186***	0.4447	-4.76	0.000
INF	-0.044	0.0116	-3.81	0.000
$CORR$	-0.3370	0.2055	-1.64	0.101
$CONTIGUITY$	-0.3559	0.5054	-0.70	0.481
$OFFICIAL\ LANG$	1.0686***	0.3889	2.75	0.006
FTA	0.8339***	0.1477	5.64	0.000
$COMMON\ COL.$	1.1253**	0.4734	2.38	0.017
$ETHNIC\ LANG$	2.5457***	0.5803	4.39	0.000
Wald	**478.22**			
$\boldsymbol{ADJ.R^2}$	**0.5871**			
Obs	**538**			

Note: dX_i*-Implies that variable has been differenced; *** and ** indicate statistical significance at one and five percent respectively*

The regression results show that higher stock of transport infrastructure of the exporting country has more capacity to increase EAC's exports volume. From the findings, an increase in the stock of transport infrastructure of the exporting country in EAC by 10 percent increases exports by 7.4 percent. The expectation is that improved infrastructure should encourage trade by reducing transportation costs since high transport costs discourage cross-border trade. These study findings support previous findings by Celbis et al. (2014), Clark et al. (2004), Francois and Manchin (2006), Grigoriou (2007), and Behar and Manners (2008). However, the impact of importer country's transport infrastructure though positive, is not statistically significant in influencing exports. In some cases, it is not only the exporting countries' infrastructure that may matter for trade. Infrastructure of the destination and condition of infrastructure in the transit economies play important functions in promoting bilateral trade (Limao and Venables, 2001; Grigoriou, 2007). Although for countries with different economic characteristics, both exporting and importing country's infrastructure may not always move in the same direction in promoting trade.

ICT infrastructure is important in international trade since it results in simpler custom procedures and consequently more trade by reducing communication costs. Boosting ICT infrastructure stock would promote bilateral trade among the Partner States EAC. Specifically, a 10 percent increase in the stock of ICT infrastructure of the exporter nation results in a 10.3 percent increase in bilateral exports in EAC. Similarly, the ICT infrastructure of the importing country is also an important driver for bilateral trade. Increasing the stock of ICT infrastructure of the importer country by 10 percent, bilateral exports rise by 8.1 percent. This means that more stock of ICT infrastructure is linked to increased exports among the EAC's Partner States. The findings are similar to those of Portugal-Perez and Wilson (2012) and Francois and Manchin (2006) who found that ICT infrastructure promote exports. In general, ICT infrastructure is essential since it promotes efficiency which leads to more trade in general.

The exporters and importers GDP have a positive relationship with exports in EAC. The findings conform to gravity model of international. Growth in GDP indicate a greater capacity for domestic production and hence the ability of a country to export. An increase in importer's GDP increases exports of the exporting country due to increased marginal propensity to import of the importing country. Based on this argument, if the GDP of the EAC countries grows by 10 percent, exports to the EAC regions would grow by approximately 12.5 percent. These results support the findings by De (2006), Bensassi et al. (2014) and Ismail and Mahyideen (2015). However, the GDP coefficients of the exporter country are larger than those of the importing country. This implies that exporting country's GDP would influence exports more as compared to importing country's GDP. This is an indication that large countries in terms of economic size would generally export more to smaller countries and import less from them.

Distance negatively affects EAC's exports. An increase in distance among the Partner States by 10 percent would lower exports within the region by 21.2 percent. The findings are in line with theoretical foundations of gravity model that geographical distance is a hindrance to bilateral trade through higher transactions costs. Higher transport costs are associated with longer distance, hence reduced profit margins and reduced volume of trade in terms of exports. Distance creates barriers to trade, consequently lowering bilateral trade. Hence, the shorter the distance, the greater the volume of trade between countries. Infrastructure development can serve by reducing distance and transport costs thereby increasing the volume of exports.

The findings reveal a positive relationship between exporters and importers population and exports. A high population by the importing country signifies a larger market size, hence higher imports. An increase in the population of the EAC's importing countries by 1 percent would result in an increase in intra-EAC exports by about 11.6 percent. Similarly, an increase in the population size of the exporting country by 1 percent would increase exports by 24.3 percent.

The existence of Free Trade Area (FTA) or EAC regional trade agreements has the expected positive sign and statistically significant. This implies that intra-EAC is 2.3 times[34] more because of the EAC customs union than with other countries who are not members of EAC. Therefore, free trade agreements are important for intra-EAC exports. EAC has therefore achieved trade creation effects through regional integration agreements. Theoretically, free trade agreements are expected to lower trade barriers between countries and consequently increase trade.

Common official and ethnic languages are important for trade in EAC. The EAC Partner States are more likely to trade amongst themselves due to the presence of common official and ethnic languages in the region. Common official and ethnic languages between trading partners lowers communication costs and therefore increasing exports. This is because if populations of two countries speak the same language, there will be ease of communication, reduced misunderstandings and associated transactional complexities. Consequently, it will be easier to trade with each other due to reduced costs. These results support the findings by Fink et al. (2005) and Fidrmuc and Fidrmuc (2016). The results also reveal that countries that share a common colonial background in EAC are likely to trade more.

Inflation negatively impacts bilateral exports in EAC. A rise in domestic inflation by 10 percent lowers bilateral exports by 0.4 percent in EAC. Inflation makes domestic goods relatively expensive, hence discouraging exports. The results also reveal that a depreciation in exchange rate would result in more exports in the EAC region. To capture the role of

[34]Since bilateral exports are in logs, the coefficients are interpreted as exponents i.e., exp (0.83) = 2.3

business environment and governance in trade, the study included control of corruption as one of the explanatory variables. However, it is not statistically significant in determining exports in the EAC region. Similar results were obtained for contiguity variable.

4.6.5 Robustness Checks for Transport and ICT Infrastructure and Intra-EAC Trade

For robustness checks, PPML estimation technique and fixed regression method were performed (Table 4.9 and Table 4.10).

Table 4.9: Effect of Transport and ICT Infrastructure on EAC Trade

Dependent Variable: Exports				**Method: PPML**
Variable	**Coefficient**	**Std. Error**	**z**	**P|z|**
$dLog\ of$ GDP_i	0.906***	0.09	9.89	0.000
$dLog\ of$ GDP_j	0.830*	0.50	1.66	0.096
$dLog\ of$ POP_i	13.228**	6.53	2.03	0.043
$dLog\ of$ POP_j	2.463	4.43	0.56	0.579
$dTRANS.INFRA_i$	1.640***	0.34	4.84	0.000
$dTRANS.INFRA_j$	0.530*	0.30	1.76	0.078
$dICT\ INFRA_i$	1.780***	0.44	4.00	0.000
$dICT\ INFRA_j$	-0.651*	0.37	-1.76	0.078
RER	0.511	0.80	0.64	0.520
$dLog\ of\ FDI$	-0.002	0.04	-0.05	0.962
$Log\ of DIST$	-1.220***	0.14	-8.57	0.000
INF	0.011	0.01	1.50	0.134
$CORR$	0.425**	0.17	2.46	0.014
$CONTIGUITY$	0.933***	0.17	5.61	0.000
$OFFICIAL\ LANG$	-0.240	0.25	-0.98	0.326
FTA	0.529***	0.13	3.95	0.000
$COLT$	0.212	0.16	1.30	0.193
$ETHNIC\ LANG$	1.724***	0.18	9.48	0.000
Pseudo log-likelihood	**-6359764.8**			
$\boldsymbol{ADJ.R^2}$	**0.760**			
Obs	**538**			

Note:dX_i*-Implies that variable has been differenced; *** and ** imply statistical significance at one and five percent respectively*

The findings in Table 4.9 show that most of the coefficients have similar signs and comparable to regression results performed under random effects regression in Table 4.8. Specifically, the transport and ICT infrastructures of the exporting country have a larger effect on exports compared to that of the importing country.

Fixed effects regression was also conducted as shown in Table 4.10. However, variables that do not change over time were omitted.

Table 4.10: Effect of Transport and ICT Infrastructure on Intra-EAC Trade

Dependent Variable: Log of Exports				**Method: Fixed Effects**
Variable	**Coefficient**	**Std. Error**	**t**	**P>$\|t\|$**
$dLog\ of$ GDP_i	1.280***	0.47	2.70	0.007
$dLog\ of$ GDP_j	0.328	0.48	0.69	0.491
$dLog\ of$ POP_i	26.564***	5.24	5.07	0.000
$dLog\ of$ POP_j	16.246***	5.11	3.18	0.002
$dTRANS.INFRA_i$	0.941*	0.53	1.77	0.078
$dTRANS.INFRA_j$	1.342**	0.53	2.48	0.013
$dICT\ INFRA_i$	0.826*	0.42	1.97	0.050
$dICT\ INFRA_j$	0.349	0.42	0.84	0.403
RER	2.378***	0.17	13.70	0.000
Log of FDI	0.056	0.03	2.02	0.044
$Lof\ of\ DIST$	Omitted			
INF	0.001	0.01	0.17	0.865
$CORR$	0.447**	0.18	2.47	0.014
$CONTIGUITY$	Omitted			
$OFFICIAL\ LANG$	Omitted			
FTA	0.152	0.15	1.04	0.297
$COLT$	Omitted			
ETHNIC LANG	Omitted			
F(14, 404)	**48.75**	**P>F=0.000**		
$\boldsymbol{ADJ.R^2}$	**0.6282**			
Obs	**538**			

*Note: dX_i-Implies that variable has been differenced; *** and ** indicate statistical significance at one and five percent respectively*

The results from the fixed effects regression indicate that the transport infrastructures of both the exporter and importer economies have positive effect on trade. The ICT infrastructure of the exporting country boosts intra-EAC exports. The GDP of the exporting countries are also important for the intra-EAC trade. These results are generally robust and similar to regression results reported in Table 4.8.

4.6.6 Soft Infrastructure and Trade in EAC

Other than determining the role of hard infrastructure (transport and ICT), the study further analysed the effect of soft infrastructure on intra-EAC. The study used burden of custom procedures, time taken to export, and cost required to export as indicators of soft infrastructure. The selected variables can also be employed as measures for infrastructure quality.[35] The model was estimated using a random effects regression technique (Table 4.11).

Table 4.11: Soft Infrastructure and Intra-EAC Trade

Dependent Variable: Log of Exports			**Method: Random Effects**	
Variable	**Coefficient**	**Std. Error**	**z**	**P|z|**
$dLog\ of$ GDP$_i$	1.1371*	0.6878	1.65	0.098
$dLog$ GDP$_j$	0.4948**	0.2458	2.01	0.044
$dLog\ of$ POP$_i$	1.8529	1.1923	1.55	0.12
$dLog\ of$ POP$_j$	0.3224***	0.1012	3.19	0.001
$Log\ of\ DIST$	-1.4427**	0.5905	-2.44	0.015
$dICT\ INFRA_i$	0.8014***	0.2761	2.90	0.004
$dICT\ INFRA_j$	0.5839***	0.2789	2.09	0.036
BCP	-0.0029	0.0038	-0.75	0.451
$LCEXP$	-0.9195***	0.1896	-4.85	0.000
$LTEXP$	-0.0345***	0.0108	-3.18	0.001
RER	0.0471	1.1381	0.04	0.967
Log of FDI	0.0776*	0.0469	1.65	0.098
INF	-0.0054***	0.0013	-4.44	0.000
$CORR$	1.6622***	0.5957	2.79	0.005
$CONTIGUITY$	-0.3084	0.3541	-0.87	0.384
$OFFICIAL\ LANG$	0.3738	0.5555	0.67	0.501
FTA	Omitted	-	-	-
$COLT$	0.3582	0.4425	0.81	0.418
ETHNIC LANG	2.1970***	0.5122	4.29	0.000
Constant	-3.8042	7.3716	-0.52	0.606
Wald	**212.30**			
$\boldsymbol{ADJ.R^2}$	**0.8238**			
Obs	**160**			

*Note: dX_i-Implies that variable has been differenced; *** and ** indicate statistical significance at one and five percent respectively*

[35]Studies by Bensassi et al. (2014) have used such measures.

High costs incurred during exportation of goods in terms of documentary compliance[36] hinders exports in EAC. A rise in cost to export with respect to documentary compliance by 10 percent lowers bilateral exports in EAC by 9.2 percent (Table 4.11). High cost incurred to export a given amount of goods hinders firms from exporting their products across the border. The findings are similar to that of Shinyekwa and Ntale (2017). Infrastructure development is important in lowering cost of trade through reduction of general delays and thereby increasing the volume of exports. Therefore, reducing the number of documents necessary to export a given quantity of goods would increase intra-EAC trade.

Time taken to carry out inspection and clearance procedures by government agencies at the ports and border points dampens exports by EAC Partner States. The longer the time required to export goods across the border in terms of border compliance, the lower the exports in EAC. A reduction in time required to clear goods by 10 percent would lead to an export growth by 0.3 percent. These findings are consistent with most findings in literature that improving border efficiency increases trade (United States International Trade Commission, 2009; Bensassi et al, 2014; Shinyekwa and Ntale 2017). Cost and time to export reflect the role of infrastructure quality on trade. Lower levels of infrastructure quality are associated with high transport costs resulting from increased fuel consumption and more time spent on transportation hence lower trade levels. As such, enhancing the quality of existing infrastructure will increase efficiency at border points and reduce associated trade costs and consequently boost exports among the EAC Partner States.

The burden of custom procedure does not significantly affect exports in EAC. The coefficients of other variables used in the model for example GDP, population and distance are correctly signed and consistent with theory. ICT infrastructure is also important in increasing exports in the EAC region. The results further show that ethnic languages are likely to promote intra-EAC trade than the official languages used in these countries. This is because most trade is likely to occur between border communities that share ethnic languages. Control of corruption is also important in increasing the volume of exports in EAC. The results support the idea that countries with better quality institutions have a comparative advantage which promotes international trade. The results are consistent with previous findings by Levchenko (2004), de Jong and Bogmans (2010), Francois and Manchin

[36]Documentary compliance refers to time and cost required to comply with documents of all government agencies of the exporting country, importing country and any transit country. It measures the entire burden of preparing all documents that will enable trade to take place between trading partners.

(2013), Beverelli et al. (2018) and Lin et al. (2018). Inflation has very minimal effects on EAC exports.

4.6.7 Transport and ICT Infrastructures and Manufactured Exports in EAC

The study went further and analysed how transport infrastructure influences trade in manufactured products in EAC. The regression results using random effects estimation are presented in Table 4.12.

Table 4.12: Transport and ICT Infrastructures and Manufactured Exports in EAC

Dependent Variable: Log of Manufactured Exports			**Method: Random Effects**	
Variable	**Coefficient**	**Std. Error**	**z**	**P|z|**
$dLog\ of$ GDP$_i$	1.8268**	0.8818	2.07	0.038
$dLog$ of GDP$_j$	1.6914*	0.8662	1.95	0.051
$dLog\ of$ POP$_i$	-6.8394*	4.0706	-1.68	0.093
$dLog\ of$ POP$_j$	5.1920	3.8097	1.36	0.173
$dTRANS.INFRA_i$	2.0270***	0.7271	2.79	0.005
$dTRANS.INFRA_j$	0.6786	0.7392	0.92	0.359
$dICT\ INFRA_i$	1.1443*	0.6932	1.65	0.099
$dICT\ INFRA_j$	1.2665*	0.6853	1.85	0.065
RER	-0.1232	0.1371	-0.90	0.369
Log of FDI	-0.1046**	0.0415	-2.52	0.012
Log of DIST	-1.5308***	0.3751	-4.08	0.000
INF	-0.0319**	0.0145	-2.21	0.027
CORR	-0.6946	0.7324	-0.95	0.343
CONTIGUITY	1.0578***	0.3982	2.66	0.008
OFFICIAL LANG	-0.0472	0.5094	-0.09	0.926
FTA	1.7820***	0.2065	8.63	0.000
ETHNIC LANG	2.2990***	0.5080	4.53	0.000
Wald	**408.37**			
R^2	**0.5060**			
Obs	**400**			

*Note: dX_i-Implies that variable has been differenced; *** and ** indicate statistical significance at one and five percent respectively*

The regression results for in Table 4.12 for manufactured exports indicate that most of the coefficients reflect the findings in Table 4.8 for general exports. Increasing the level of transport infrastructure of the exporting country by 10 percent would enhance manufactured goods' exports to the region by 20.3 percent. The results also show that the ICT infrastructure of both the exporter and importer nation's infrastructure is an important determinant of intra-EAC's manufactured exports.

The effect of exporting country's GDP on manufactured exports is positive for EAC Partner States. This implies that growth in GDP would significantly increase the volume of manufactured exports to the region. This is also similar for importing country's GDP which is also positive and statistically significant at 10 percent.

Longer distance increases transaction costs thus lowering the volume of bilateral manufactured exports in EAC. As predicted, the coefficient of distance is negative. Longer distance results in higher transport costs which negatively impacts on export volumes. The findings also show that higher inflation negatively affects trade in manufactured goods. Higher foreign direct investments inflow has a negative impact on exports of manufactured goods. This could be linked to the fact that some of the foreign direct investments could be directed to the manufacturing sector which may reduce importation of manufactured goods by the recipient countries.

Economies that have a common border are likely to trade more with one another since crossing the border could be relatively easier than those without a common border. From the results, EAC Partner States that have a common border are 3 times more likely to export manufactured products than countries without a common border.

The role of free trade agreements in promoting manufactured exports in the region cannot be underestimated. The EAC partner states are more likely to export manufactured goods to their counterparts due to the regional trade agreements. The results, therefore, support the fact that sharing a common language is associated with lower information costs hence more trade. For example, Tanzania shares some ethnic languages with Kenya while Uganda shares common ethnic language with Kenya and Rwanda and therefore more likely to export manufactured products to these countries. This is because countries that have a common language may have similar cultural practices and may easily understand each other's business environment and practices which reduces search costs. The findings corroborate the results by Fink et al. (2005) and Fidrmuc and Fidrmuc (2016). The impact of control of corruption index and common official language on manufactured exports in EAC were not statistically significant.

For robustness check regression using PPML estimator was done (Table 4.13).

Table 4.13: Transport and ICT Infrastructures and Manufactured Exports in EAC

Dependent Variable: Manufactured Exports				**Method: PPML**
Variable	**Coefficient**	**Std. Error**	**z**	**P|z|**
ΔLGDP$_i$	1.3799***	0.1260	10.95	0.000
ΔLGDP$_j$	0.1614**	0.0809	1.99	0.046
ΔLPOP$_i$	-7.7060*	4.3797	-1.76	0.079
ΔLPOP$_j$	-1.7091	1.8258	-0.94	0.349
$\Delta TRANS.INFRA_i$	0.0970	0.1589	0.61	0.542
$\Delta TRANS.INFRA_j$	0.5968*	0.3301	1.81	0.071
$\Delta ICT\ INFRA_i$	0.9964***	0.3447	2.89	0.004
$\Delta ICT\ INFRA_j$	0.2687***	0.0896	3.00	0.003
$LRER$	0.0103	0.1113	0.09	0.926
$LFDI$	0.0267	0.0335	0.75	0.451
$LDIST$	-0.5732***	0.1859	-3.08	0.002
INF	-0.0159**	0.0064	-2.47	0.014
CORR	-0.8454***	0.1234	-6.85	0.000
CONTIGUITY	0.9313***	0.1710	5.45	0.000
OFFICIAL LANG	-0.1904	0.1722	-1.11	0.269
FTA	0.0035	0.1644	0.02	0.983
ETHNIC LANG	1.0110***	0.1840	5.49	0.000
Log-likelihood	**-2101671.8**			
$\boldsymbol{R^2}$	**0.8499**			
Obs	**400**			

*Note: ΔX_i-Implies that variable has been differenced; *** and ** indicate statistical significance at one and five percent respectively*

The importance of ICT infrastructure in enhancing manufactured exports in EAC is still significant under PPML regression model. Transport infrastructure for the importing country is also significant in influencing manufactured exports. The coefficients of other regressors in the model such as real GDP, inflation, contiguity, distance and ethnic language are correctly signed and similar to earlier regressions.

4.6.8 Transport Infrastructure, Institutions and Inter-EAC Trade

This section analyses the relationship between infrastructure development, institutional quality and inter-EAC trade. It focuses on transport infrastructure, quality of institutions and exports from EAC to three regional economic blocs in SSA. These include SADC[37], ECOWAS[38] and ECCAS[39]. There exist multiple memberships between some Partner States in EAC and other regional economic blocs in SSA. For example, Tanzania is a Partner State EAC and a Member State SADC, Rwanda and Burundi are both in EAC and ECCAS, therefore, to control for overlapping membership, a dummy variable for multiple membership was used in the regression.

Data for transport infrastructure for all the regional economic blocs was obtained from AfDB Socio-Economic database, covering a 20-year period, from 2000 to 2019. In addition, the role of institutions in promoting inter-regional trade was investigated. This was achieved by incorporating institutional variables in the gravity model. The variables include common religion dummy, control of corruption index and regulatory quality.

4.6.8.1 Transport Infrastructure, Institutions and EAC-SADC Trade

Relationship between transport infrastructure and trade between EAC and SADC was analysed as shown in Table 4.14. Institutional variables were captured by control of corruption index and regulatory quality. Regression was done using PPML estimator.

The results in Table 4.14 indicate that both exporter's and importer's transport infrastructure are important for inter-regional trade. At 10 percent level of significance, a boost in stock of transport infrastructure in EAC by 1 percent increases volume of exports to SADC region by 0.7 percent. Likewise, at 1 percent level of significance, an improvement in SADC's infrastructure by 1 percent increases the volume of EAC's exports by 0.9 percent. This implies that the importer country's infrastructure matters more for export trade than that of the exporter country.

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[37] SADC has 16 Member States: Angola, Botswana, Comoros, DRC, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Tanzania, Zambia and Zimbabwe. Source: https://www.sadc.int/member-states/.

[38] ECOWAS has 15 Member States: Benin, Burkina Faso, Cabo Verde, Cote D'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo. Source: https://www.ecowas.int/member-states/.

[39] ECCAS has 11 Member States: Angola, Burundi, Cameroon, Central African Republic, Chad, Congo, DRC, Equatorial Guinea, Gabon, Sao Tome Principle and Rwanda. Source: http://www.ceeac-eccas.org/index.php/fr/.

The nature of institutions of the exporter countries in terms of regulatory quality enhance the volume of exports between regional economic blocs in SSA. The relationship between regulatory quality and EAC-SADC exports is positive. Improving the regulatory quality in the EAC region by 1 percent has the potential of increasing the volume of exports to the SADC region by 1.9 percent. The findings of this study are similar to the results by Francois and Manchin (2013) who found that quality institutions of the exporter country are more likely to foster trade than those of the importing country.

Table 4.14: Effect of Transport Infrastructure and Institutions on EAC-SADC Trade

Dependent Variable: Exports				**Method: PPML**
Variable	**Coefficient**	**Std. Error**	**z**	**P|z|**
$dLog\ of$ GDP$_i$	0.855***	0.23	3.75	0.000
$dLog\ of$ GDP$_j$	0.068	0.35	0.19	0.846
$dLog\ of$ POP$_i$	-0.297	0.68	-0.43	0.664
$dLog\ of$ POP$_j$	2.088***	0.14	14.43	0.000
$Log\ of\ DIST$	-2.198***	0.37	-6.00	0.000
$dTRANS.INFRA_i$	0.693*	0.36	1.95	0.051
$dTRANS.INFRA_j$	0.927***	0.26	3.55	0.000
$dCORR_i$	-1.202	0.84	-1.44	0.151
$CORR_j$	0.482***	0.16	3.00	0.003
$dREGQ_i$	1.869**	0.85	2.20	0.027
$dREGQ_j$	0.250	0.32	0.79	0.432
$Log\ of\ AREA_i$	0.589***	0.21	2.84	0.004
$Log\ of\ AREA_j$	-0.145	0.12	-1.23	0.217
$CONTIGUITY$	-0.340	0.22	-1.52	0.129
$OFFICIAL\ LANG$	-0.386	0.40	-0.97	0.334
$ETHNIC\ LANG$	-0.207	0.19	-1.09	0.277
WTO	0.354	0.27	1.30	0.194
$COMMON\ REL.$	8.210***	1.76	4.67	0.000
MM	0.618**	0.246	2.51	0.012
$CONS$	-39.185***	5.06	-7.74	0.000
Pseudo log-likelihood	**-12684.40**			
$\boldsymbol{R^2}$	**0.6771**			
Obs	**1350**			

*Note: dX_i-Implies that variable has been differenced; *** and ** indicate statistical significance at one and five percent respectively.*

Control of corruption index of EAC has a negative but not statistically significant relationship with exports to SADC region. However, improvement in control of corruption in SADC has a positive effect on EAC's exports. These findings support studies by Yu et al. (2015) and

Alvarez et al. (2018). The results also show that EAC-SADC countries are likely to trade because they have religious affiliations. From the findings, the presence of common religion between countries in the EAC and SADC is more likely to increase exports from EAC than in absence of a common religion.

The dummy for multiple memberships (MM) promotes EAC's exports. This implies that EAC is likely to export more to the SADC region if there exist countries that belong to the two RECs. For example, Tanzania is a member of EAC and SADC, therefore, likely to export more to SADC, consequently increasing exports from EAC. The rest of the explanatory variables for example, exporting country's GDP, population of the destination country and distance have the expected signs. The dummy variable for official language has a negative sign but not statistically significant. Similarly, the contiguity dummy is negatively signed but not statistically significant. The impact of WTO agreements is positive albeit not statistically significant (Table 4.14). This could be linked to the dominance of free trade agreements under EAC and SADC which leads to duplication of efforts, rendering the WTO agreements insignificant. These results support the findings by Rose (2004) and Roy (2011) revealed that joining WTO has no impact on bilateral trade.

4.6.8.2 Transport Infrastructure, Institutions and EAC-ECOWAS Trade

The impact of transport infrastructure and quality of institutions on the exports from EAC to ECOWAS was investigated (Table 4.15). The estimation was done using PPML estimation method.

The results for EAC-ECOWAS trade are comparable to that of EAC-SADC trade in Table 4.14 for most of the variables. Transport infrastructure of exporter and importer economies is important for trade. Improving the quality and stock of EAC's transport infrastructure by 1 percent has the potential of increasing the volume of EAC exports to ECOWAS by 0.5 percent. Similarly, increasing the quality and stock of transport infrastructure in ECOWAS region by 1 percent would increase EAC's exports by 0.4 percent.

Table 4.15: Effect of Transport Infrastructure and Institutions on EAC-ECOWAS Trade

Dependent Variable: Exports				**Method: PPML**
Variable	**Coefficient**	**Std. Error**	**z**	**P|z|**
$dLog\ of$ GDP_i	2.405***	0.26	9.16	0.000
$dLog\ of$ GDP_j	0.810**	0.37	2.22	0.026
$dLog\ of$ POP_i	-7.672***	0.99	-7.75	0.000
$dLog\ of$ POP_j	-30.042	26.37	-1.14	0.255
$Log\ of\ DIST$	-2.096***	0.74	-2.83	0.005
$dTRANS.INFRA_i$	0.514***	0.21	2.64	0.008
$dTRANS.INFRA_j$	0.425***	0.15	2.93	0.003
$dCORR_i$	0.234	1.02	0.23	0.818
$dCORR_j$	1.904***	0.6206	3.07	0.002
$REGQ_i$	0.816*	0.44	1.84	0.066
$REGQ_j$	-0.163	0.20	-0.83	0.407
$LAREA_i$	3.725***	0.30	12.43	0.000
$LAREA_j$	0.748***	0.11	7.12	0.000
OFFICIAL LANG	0.658***	0.25	2.66	0.008
ETHNIC LANG	1.643***	0.21	7.78	0.000
WTO_j	0.676***	0.44	1.55	0.001
COMMON REL.	-4.470***	1.22	-3.67	0.000
CONS	34.014***	12.39	2.74	0.006
Pseudo log-likelihood	**-12411.82**			
R^2	**0.7020**			
Obs	**1350**			

*Note: dX_i-Implies that variable has been differenced; *** and ** indicate statistical significance at one and five percent respectively*

Improvement in control of corruption index in the ECOWAS region has a positive relationship with exports from EAC. At the same time, the regulatory quality of the EAC Partner States is positively linked with the volume of exports to ECOWAS. The findings are consistent with results by Yu et al. (2015) and Alvarez et al. (2018). The effect of WTO trade agreements is positively signed, signifying the important role of trade of trade agreements in promoting trade in SSA.

The GDP of both the EAC Partner States and countries in the ECOWAS enhances EAC's exports. If the GDP of the EAC Partner States increases by 1 percent, then their exports to the ECOWAS region increase by 2.4 percent. Similarly, if the GDP of the countries in the ECOWAS region increases by 1 percent, exports from EAC increases by 0.8 percent. The population of EAC has a negative relationship with EAC's exports. This may be linked to the fact that an increase in population of the exporter may encourage more domestic consumption, hence discouraging exports. The results corroborate the findings by Turkson (2012) in a study involving countries in SSA. Distance has a negative impact on EAC's exports. An increase in distance between EAC and ECOWAS will lower exports from EAC to ECOWAS region. There is a positive relationship between land area of both the EAC and ECOWAS countries and exports from EAC. This is in line with the findings by Behar and Manners (2008) and Turkson (2012).

Official and ethnic languages also play important roles in promoting exports from the EAC region. Common language between two countries is known to foster bilateral trade due to reduced communication costs. Common language is known to reflect similar cultural and business practices hence more trade. Therefore, EAC Partner States are more likely to trade with countries in ECOWAS if they share official and ethnic languages than with other countries. The results corroborate the findings by Nordas and Piermartini (2004). For example, according to CEPII database, Burundi and Rwanda share official and ethnic languages with countries in ECOWAS region such as Benin, Burkina Faso and Guinea.

4.6.8.3 Transport Infrastructure, Institutions and EAC-ECCAS Trade

The analysis of the effect of transport infrastructure and institutions on exports from EAC to ECCAS region was done using PPML estimator (Table 4.16).

The results further affirm the important contribution of transport infrastructure in boosting inter-regional trade. Increasing the quality and stock of transport infrastructure by 10 percent increases EAC's exports to ECCAS region by 6.8 percent. However, an increase in stock of transport infrastructure for the ECCAS region positively influences EAC's exports albeit not statistically significant.

It is also notable that the quality of institutions in promoting the volume of exports from EAC cannot be underscored. Improvement in measures to curb corruption by the EAC Partner States has a positive effect on the exports to ECCAS region. Similarly, better control of corruption in the ECCAS region has a positive influence on EAC's export volumes. The results further indicate that regulatory qualities of both the EAC and ECCAS region encourages EAC's exports. This is an indication that the volume of exports from EAC to ECCAS would increase if the regulatory environment improves for both the EAC and

ECCAS regions. The findings of this study support previous studies by de Jong and Bogmans (2010), Yu et al. (2015) and Alvarez et al. (2018).

Table 4.16: Effect of Transport Infrastructure and Institutions on EAC-ECCAS Trade

Dependent Variable: Exports				**Method: PPML**
Variable	**Coefficient**	**Std. Error**	**z**	**P|z|**
$dLog\ of$ GDP$_i$	2.221***	0.78	2.85	0.004
$dLog\ of$ GDP$_j$	0.365*	0.21	1.76	0.079
$dLog\ of$ POP$_i$	0.712	0.77	0.93	0.354
$dLog\ of$ POP$_j$	2.41***	0.46	5.20	0.000
$Log\ of\ DIST$	-8.984***	1.86	-4.82	0.000
$dTRANS.INFRA_i$	0.679**	0.31	2.18	0.029
$dTRANS.INFRA_j$	0.988	2.45	0.40	0.687
$CORR_i$	0.710***	0.17	4.17	0.000
$CORR_j$	2.786***	0.90	3.08	0.002
$REGQ_i$	1.507*	0.85	1.77	0.077
$REGQ_j$	1.743***	0.65	2.66	0.008
$LAREA_i$	1.486*	0.83	1.80	0.073
$LAREA_j$	-3.319***	0.94	-3.51	0.000
OFFICIAL LANG	2.245***	0.38	5.81	0.000
ETHNIC LANG	0.042	0.43	0.10	0.921
WTO_j	16.360***	4.57	3.57	0.000
MM	1.594	1.40	1.14	0.255
CONS	21.018	16.05	1.31	0.190
Pseudo log-likelihood	**-3682.37**			
$\boldsymbol{R^2}$	**0.7523**			
Obs	**809**			

Note: ΔX_i*-Implies that variable has been differenced; *** and ** show statistical significance at one and five percent respectively*

The GDPs of both EAC Partner States and ECCAS countries have a direct link with exports from EAC. If the GDP of the EAC Partner States increases by 1 percent, then their exports to the ECCAS region increase by 2.2 percent. On the other hand, if the GDP of ECCAS countries increase by 1 percent, exports from the EAC increases by 0.4 percent. Another important determinant of trade between EAC and ECCAS is distance, the longer the distance, the lower the exports from EAC.

An increase in the population size of the ECCAS region leads to growth of EAC's exports. A large population of the importer implies a large market size which encourages exports. Official language also play an important role in promoting exports from the EAC region.

Therefore, EAC Partner States are more likely to trade with countries in ECCAS if they share official languages than with other countries. For example, according to CEPII database, Burundi and Rwanda shares French language with countries in ECCAS region such as Cameroon, Congo, DRC and Gabon. The dummy for WTO trade agreements is positively signed and statistically significant, signifying the important role of trade agreements in promoting trade between EAC and ECCAS regions. The dummy for multiple memberships is positive but not statistically significant for the EAC-ECCAS regression.

4.7 Summary, Conclusions and Policy Implications

4.7.1 Summary

A gravity model was estimated to analyse the link between infrastructure development and trade in the EAC using data for 5 EAC Partner States from 1990-2019. The study constructed a transport infrastructure index using data from World Bank and AfDB socio economic database 1960-2021. Export data was sourced from World Bank's WITS data base while other independent variables were sourced from CEPII and WDI database. The institutional variables such as regulatory quality and control of corruption were obtained from the WGI from the World Bank.

This study focused on how infrastructure development affects bilateral exports among EAC Partner States. Gravity model was used to determine the role of transport and ICT infrastructures in influencing intra- and inter-regional exports volume in EAC. A good understanding of this relationship could be crucial for improvement of EAC's infrastructure policy actions.

The study also employed a gravity model augmented for transport related infrastructure variables for intra-EAC trade. The key findings from this study confirmed the crucial position of transport infrastructure in enhancing trade in the EAC. The results show that infrastructure of the exporter Partner State is critical in determining bilateral exports than the infrastructure of the recipient country. Specifically, transport infrastructure of the exporting country was more important in promoting bilateral exports than infrastructure of the destination country. This could be the reason why the volume of exports in many developing countries is low and therefore, perform poorly in world trade.

The findings also confirmed the crucial role of ICT in promoting general exports in the EAC. However, the study established that transport infrastructure has a relatively larger effect on bilateral exports than ICT infrastructure in the EAC.

The study also established the role of soft infrastructure in explaining EAC's exports. With respect to soft infrastructure measures, the cost of exports in relation to time to export and documents were the important variables determining bilateral exports in the EAC. The study found a negative link between the cost of exporting goods and exports in the EAC. In addition, longer time taken to clear goods for export goods in terms of border compliance lowers exports volume in the EAC.

The results confirm that the regional trade agreements under the EAC customs union encourages intra-EAC trade. The estimates from the gravity model on the role of EAC customs union on exports found that the free trade agreements are 3 times more likely to promote intra-EAC trade. Other than infrastructure variables, other important variables in explaining trade in EAC include real GDP, distance and common ethnic language.

The study also investigated the role of transport and ICT infrastructures in influencing manufactured exports to the region. The study established that transport infrastructure plays a more crucial role than ICT infrastructure in promoting the exports of manufactured goods within the region.

Free trade agreements also emerged as the most important factor in promoting the exports of manufactured products among the EAC Partner States. Free trade agreements entail lowering barriers to trade thereby lowering costs incurred during trade.

Using data from AfDB on transport infrastructure and data on institutions from WGI of the World Bank, the study investigated the role of transport infrastructure and institutions in promoting inter-regional trade in SSA. To do this, the study established the performance inter-EAC trade by focusing on trade between EAC and three other regional economic blocs in SSA namely SADC, ECOWAS and ECCAS.

The study estimated an augmented gravity model using PPML and established that transport infrastructure and institutions play important roles in determining the trade volume between EAC and other economic blocs in SSA. The results confirm that both importers and exporters transport infrastructure positively influence exports from EAC to other regional economic blocs. Specifically, it is worth noting that domestic infrastructure (EAC’s transport infrastructure) play a larger role than importers infrastructure (SADC, ECOWAS and ECCAS) in promoting the volume of exports. While both transport infrastructure in SADC and ECOWAS significantly influence the volume of exports from the EAC. The impact of ECCAS’ transport infrastructure on EAC’s exports was positive, though not statistically significant.

Improvement in quality of institutions of the importer regional economic bloc has a positive contribution to exports from EAC. The study used regulatory quality and control of corruption as indicators for institutional variables. The results show that enhancement of control of corruption measures in ECOWAS and ECCAS could significantly boost the volume of exports from EAC. Control of corruption index for SADC countries is not an important determinant of EAC's exports. This could be linked to the fact that SADC member countries have relatively better-quality institutions than those in ECOWAS and ECCAS and therefore any further improvement does not significantly influence EAC's exports. However, the effect of improvement in corruption index of the EAC Partner States on exports was not statistically significant for SADC and ECOWAS regions but positive and statistically significant for ECCAS region.

Improvement in regulatory quality of the exporting countries in EAC positively impacts on EAC's exports to SADC, ECOWAS and ECCAS. Regulatory quality is concerned with the business environment, in particular, how government policies and regulations affect private sector development. This implies that if government policies and regulations are conducive to the private sector, they are likely to expand their operations in terms of investments, production and other activities. Therefore, more domestic production is likely to encourage exports.

Other important drivers of inter-EAC trade include distance which lowers EAC's exports. Growth in GDP of the exporting countries in EAC could significantly increase the volume of exports. An increase in population of other regional economic blocs expands the potential market for goods from EAC hence more trade. EAC is likely to trade more with other regional blocs that they share the same official language with than other regions without a common official language. The study also established that EAC is likely to trade more with other regional economic blocs in SSA who are members of the WTO. This is because WTO aims at promoting trade between countries by eliminating trade barriers. Finally, multiple membership was found to significantly influence trade between EAC and SADC since Tanzania is a member of the two RECs.

4.7.2 Conclusions

The study established how infrastructure development affects bilateral trade in EAC and consequently the pace of economic integration. Using random effects method, the study found that both the stock of transport and ICT infrastructures significantly impact intra-and inter-EAC's exports. Therefore, EAC Partner States can accelerate the speed economic integration through higher investment in transport and ICT infrastructures that are necessary to enhance trade.

EAC Partner States are likely to realize additional benefits by enhancing the stock of both soft and hard infrastructure in the region. However, in terms of hard infrastructure, transport infrastructure contributes more to exports in comparison to ICT infrastructure. The findings are linked to the negative effects of distance in bilateral trade. This is because transport infrastructure plays a greater role in reducing transportation costs associated with long distance. Therefore, transport infrastructure is key in reducing the negative effect of distance in trade, hence outperforms ICT infrastructure.

Both exporter and importer country's infrastructure are significant in promoting bilateral exports. This means that development of infrastructure is central to the process of economic integration, which explains initiatives put in place by EAC to implement joint infrastructure projects. However, the infrastructure of the exporter country has a more critical role in influencing the volume of exports than that of the importing country.

The quality of institutions is central to intra-EAC trade. The EAC Partner States could benefit more in terms of trade by controlling corruption and improving the overall business environment. Improving the regulatory quality implies a favourable business environment for private investors hence more investments. On the other hand, improvement in overall corruption index implies less costs associated with exports of goods hence more trade.

The existence of free trade agreements is crucial for intra-EAC trade. The EAC customs union encourages more intra-EAC among the Partner States because of the regional trade agreements. The EAC customs union is meant to reduce barriers associated with trade among the Partner States in the region.

In terms of inter-regional trade, the study established how transport infrastructure development and institutions affects inter-EAC trade flows. By employing PPML estimator, the study found that the stock of transport infrastructure promotes exports from EAC to other regional economic blocs in SSA. Therefore, EAC Partner States can increase the volume of exports through increased investment in transport infrastructure which would enhance trade.

Better institutions would promote exports from EAC to other regional economic blocs in SSA. Specifically, improvement in regulatory quality of other regional blocs in SSA has a greater potential of increasing exports from EAC. The study also found that EAC Partner States would export more to other regional blocs whose members are part of the WTO trade agreements. WTO trade arrangements are also vital for inter-EAC trade. More trade is realized between EAC and other regional-economic blocs whose Partner States are members of WTO. This suggests the importance of regional trade arrangements in minimizing barriers linked with international trade.

4.7.3 Policy Implications

The EAC region is currently experiencing increased investment in infrastructure, and the partner states even have joint infrastructure policy. Therefore, the findings of this study provide an important reference point for policy makers in the EAC on what types of infrastructure to invest in for increased benefits in the region.

There is need for EAC Partner States to improve their trade related infrastructure for more trade flows. However, transport infrastructure contributes more to trade than ICT related infrastructure. Therefore, in conditions where resources are scarce, priority should be given to investments related to transport infrastructure. Ultimately, EAC Partner States can increase additional opportunities for trade through diversified production. Additionally, more investments to improve the stock and quality of transport infrastructure among the EAC Partner States will is imperative in increasing the volume of exports to other regional economic blocs within the SSA region.

It is crucial for EAC Partner States to reduce the cost of doing business for more benefits. EAC Partner States can enhance border efficiency by reducing the documentary compliance among the member states. The countries will gain more in terms of trade by minimizing the required documentation and time costs associated with exports.

Targeted investment in infrastructure is important for EAC Partner States with limited resources. For EAC Partner States that have small trade shares in EAC such as Burundi and Rwanda, increasing both quality of existing infrastructure and targeted investment in transport infrastructure would be important for increasing their trade shares and growth in general.

The role of institutions in international trade cannot be underestimated. Improving the overall regulatory environment of the EAC Partner States will go a long way in promoting exports from EAC to other regional economic blocs in SSA. This implies that it is critical for the EAC Partner States to improve the overall business environment to boost production and export by the private sector.

EAC Partner States can also increase the volume of inter-regional exports by enhancing measures to curb corruption. This can be done by leveraging technology to enhance efficiency and reduce opportunities for corrupt activities at the border points and ports.

CHAPTER TWO

SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

5.1 Summary of Findings

The study aimed at building on the existing evidence on infrastructure development and growth by doing a comprehensive analysis not only on infrastructure and growth but also on key determinants of growth such as private investment and trade. First, the study investigated the link between infrastructure stock and economic growth. Second, the effect of public investment on private investment was established to examine the possibility of crowding-out effect of public investment. Finally, the role of transport and ICT infrastructures in trade facilitation was determined by analyzing intra-and inter-EAC trade.

The results of economic growth and infrastructure stock regression are consistent with endogenous growth models that support a positive contribution of infrastructure in a growth process. Infrastructure stock does not significantly affect real GDP in EAC in the short-run, the results link this to time lags associated with infrastructure investment, hence not likely to affect growth in the short-run. In the long-run, however, infrastructure stock has positive contribution to economic growth of the EAC Partner States. Besides, the study found evidence of uni-directional causality from infrastructure stock to economic growth, implying that infrastructure promotes growth in EAC. The study also confirmed that capital stock enhances long-term economic progress. Infrastructure stock forms an important part of the growth process, however, its accumulation depends on the level of investment undertaken in a country. The role of labour force in the growth process of the EAC Partner States is manifested both in short-and long-run. This is because EAC Partner States have relatively low levels of technology and rely on labour intensive production processes hence making labour important for both short-and long-term growth.

The complementarity effect of public infrastructure investment is evidenced in EAC in the long-run. This is known as the crowding-in effect of public investment and supports the public capital hypothesis. Public capital hypothesis argue that public infrastructure investment directly or indirectly increase the productivity of private sector, hence increase in investment by the private sector. The direct effect arises from the services generated from the stock of public infrastructure which are considered intermediate services in private sector production process. On the other hand, indirect effect occurs because public capital complements private capital, implying that public capital is critical in enhancing productivity of private capital. The results, therefore, confirm that public infrastructure promotes economic growth in EAC via private investment. However, in the short-term, public investment suppresses private investment in EAC. This is linked to the fact that public investment in EAC is both domestically and externally financed, domestic financing could be linked to rise in interest rates which crowds-out private investment in the short-term. This is evidenced by the negative relationship between private investment and interest rates in EAC in the short-run.

The results confirm that real GDP is an important factor explaining the variations in private investment in EAC. This supports the accelerator theory of investment which argues that an expansion in national income leads to a rise in investment spending. The theory argues that an increase in GDP increases investment by a given multiple amount. Therefore, in the long-run, increases in GDP induce private investment in EAC through the accelerator effect. The study also found that domestic credit promotes private investment in the long-run. This implies that private investment activities are likely to increase due to availability of financial resources from financial institutions. Other regressors in the model such as external debt, real interest rate, real exchange rate and inflation do not affect private investment decisions in the long-run. Though, in the short-run, the study established that real GDP, trade openness, credit to private sector, external debt and real exchange rate do not inform private investment decisions in the EAC.

The roles of hard and soft infrastructures in determining trade volumes were investigated in the third essay of this study. First, the study analysed the role of transport and ICT infrastructures in determining intra-EAC exports. To establish the role of institutions and governance in determining intra-EAC trade, the study incorporated control of corruption as one of the regressors in the model. Lastly, the role of transport infrastructure and institutions in influencing inter-regional trade in SSA was investigated in the third essay. In this case, institutional variables were proxied by regulatory quality and control of corruption index.

The results on trade reveal that transport infrastructure is a key determinant of intra-EAC exports. The results further reveal that exporting country’s transport infrastructure play a larger role in promoting exports than that of the importing country. This could be one of the reasons why Kenya performs better in intra-EAC than her counterparts in the region because Kenya has a relatively well-developed infrastructure. Similar results were found for exports of manufactured exports in the EAC region.

ICT infrastructure is also crucial in determining exports in the EAC region. The results indicate a direct statistically significant association between ICT infrastructure and intra-EAC exports; however, the effect of transport infrastructure is stronger. This indicates that, transport infrastructure plays a more important role in promoting both aggregate and manufactured exports in EAC than ICT infrastructure.

The study investigated the role soft infrastructure in determining exports within the EAC Partner States by using the documentation mandatory for exports and time to export as proxies. The findings reveal that increase in number of documents required to export and time taken to export lowers the volume of exports in EAC.

The role of regional trade agreements in promoting intra-EAC trade cannot be underscored. The findings reveal that free trade agreements positively affect exports within the EAC region. On average, the regional trade agreement increases the likelihood of intra-EAC by more than double, as compared to trade with other countries not within the regional trade agreements.

In accordance with gravity model of international trade, the study established that real GDP positively affect exports in the EAC region while distance lowers the volume of trade. As the economy grows, the productive capacity increases hence the likelihood of exports. On the other hand, longer distance increases transportation costs hence lower exports volume. Other than the real GDP and distance, the study also established that common ethnic language is also important in increasing exports among the Partner States in the region.

The critical role of transport infrastructure in trade facilitation is also evidenced in inter-EAC trade. The study used gravity model to analyse trade between EAC and other RECs in SSA namely SADC, ECOWAS and ECCAS. Based on the findings, transport infrastructure of the exporter countries (EAC) and that of the exporting countries (SADC, ECOWAS and ECCAS) have a positive relationship with exports from EAC Partner States. However, the findings reveal that exporters infrastructure play a relatively larger role in boosting exports than that of the importing countries.

The findings from the inter-EAC trade regression model further affirm the fundamental role institutions play in promoting trade. The study established that if control of corruption index of ECOWAS and ECCAS improves, then exports from EAC increases significantly. Improvement in control of corruption index for SADC countries was positive but not statistically significant. Another institutional variable used in the model was regulatory quality which is concerned with the overall business environment with respect to private sector operations. The findings reveal a positive relationship between regulatory quality of the EAC Partner States and exports to SADC, ECOWAS and ECCAS. This implies that better regulatory quality of the EAC Partner States is associated with higher exports to other RECs in SSA.

The rest of the variables included in the inter-EAC trade regression are consistent with gravity model of international trade. Increase in GDP of the EAC Partner States increases the volume of exports to other regional blocs while distance negatively affects EAC's exports. In addition, higher population of the importing countries significantly promotes exports from EAC. The study also found that EAC Partner States are likely to export more to regions who are signatories of WTO.

5.3 Conclusions

From study results, development of infrastructure contributes to economic growth in the long-run by encouraging private investment and promoting trade in EAC. In the short-run, infrastructure development does not significantly affect economic growth in EAC. This could be linked to time lags associated with investment in infrastructure. This implies that a long-run association exist between infrastructure stock and economic growth in EAC. The overall conclusion is that the EAC should invest more in transport and energy infrastructure as this would increase private investment and promote trade. In the end, higher economic growth would be realized.

In EAC Partner States, public infrastructure investment, economic growth and trade openness are key drivers of private investment spending. Public investment crowds-out private investment in EAC in the short-term. Borrowing to finance infrastructure projects raises domestic interest rates hence crowding-out. However, in the long-term public investment complements private investment. More public infrastructure investment improves the overall business environment hence encouraging private sector activities. Private investors are attracted to regions with well-functioning transport infrastructure, stable energy sources and good telecommunications infrastructure. In addition, economic growth symbolizes as stable macroeconomic environment and strong aggregate demand which are essential for private sector investment. Inflation is an indicator of macroeconomic stability; from the findings of this study, high inflation levels discourage private investment in the short-term. A more open economy signifies ability to easily conduct trade, which is important for private investors.

Both transport and ICT infrastructures are important for intra-EAC trade facilitation. EAC Partner States are likely to enjoy more trade benefits by increasing the stock of transport and ICT infrastructures. However, transport infrastructure is associated with more trade benefits than ICT infrastructure. This is because a good transport infrastructure is more likely to reduce the negative effects associated with distance than ICT infrastructure. The findings also support the important roles that transport infrastructure play in inter-EAC trade. It is also notable that, for both intra-and inter-EAC trade, exporting country's infrastructure has a greater role in promoting exports than that of importing country.

Regional trade agreements are crucial for promoting trade within EAC Partner States. The existence of trade agreements under EAC customs union limits trade barriers hence more trade amongst EAC-Partner States. In addition, WTO trade agreements are important for promoting trade between EAC and other regional economic blocs in SSA.

Quality institutions are important for both intra-and inter-EAC trade. EAC Partner States can trade more by enhancing regulatory quality. This involves improving the overall business environment by ensuring that policies and regulations put in place encourage private sector activities. Additionally, the EAC Partner States are also likely to gain more in terms of trade by improving on governance.

5.4 Policy Implications

The study established that infrastructure stock is critical for sustained economic growth in EAC in the long-run. Building more infrastructure stock requires more investment particularly in transport, energy and ICT. Therefore, to promote growth, EAC-Partner States through their joint infrastructure policies should direct more investment towards provision of transport, energy and ICT services. However, most of the infrastructure projects among the EAC Partner States are mainly debt financed. This has led to high debt accumulation beyond recommended thresholds consequently impeding growth. It is, therefore, important for EAC Partner States to explore other alternative sources of financing infrastructure such as public-private partnerships to minimize high debt accumulation.

Infrastructure development improves the business environment for private sector development. The policy implication that can be drawn from the complementary effect of public investment in EAC is that the EAC Partner States should increase public infrastructure investment to attract more private investment in the region. In addition, it is important for EAC Partner States to pursue prudent monetary and fiscal policies that ensure a stable macro-economic environment to encourage private investment.

It is critical for the EAC Partner States to invest more to increase the stock of transport and ICT infrastructures. However, to encourage more trade, there is need to channel more resources towards transport related infrastructure as it contributes more to trade. This will require expanding the existing road and railway networks to minimize the delays experienced during the movement of goods across borders.

To promote intra-regional trade, it is important for EAC Partner States to lower trade related costs. This can be done by improving border efficiency by ensuring limited documentation and time necessary to export goods. This will require upgrading of the existing ICT systems and joint provision of relevant infrastructure at the border posts to ease cross-border trade.

It is important for EAC Partner States to improve the overall business environment by improving regulatory quality and minimizing corruption. This can be done by ensuring that policies that are formulated and regulations encourage private sector activities. This can boost the overall level of intra-and inter-EAC exports. To minimize corruption, the governments should employ more technology at the borders and intensify prosecution of those involved in corrupt practices.

REFERENCES

Abbas, S. and Mosallamy, D. (2016). Determinants of FDI Flows to Developing Countries: Empirical Study on the MENA Region, *Journal of Finance and Economics*, 4 (1): 30-38.

Abdi, H. A. and Williams, L. J. (2010). Principal Component Analysis. *WIREs Computational Statistics*. 2: 433-459.

Abe, K. and Wilson, J. S. (2008). Governance, Corruption, and Trade in the Asia Pacific Region, Policy Research Working Paper, 4371, World Bank.

AfDB, (2016). The Africa Infrastructure Development Index 2016, Nairobi, Kenya.

Agenor, P-R. Moreno, D. B. (2006). Public Infrastructure and Growth: New Channels and Policy Implications. World Bank Policy Research Working Paper 4064, Washington, DC.

Agenor, P-R. Nabli, M. K. and Yousef, T. M. (2005). Public Infrastructure and Private Investment in the Middle East and North Africa. World Bank Policy Research Working Paper No. 3661.

Ahmad, N. A., Ismail, N. W. and Nordin, N. (2015). The Impact of Infrastructure on Foreign Direct Investment in Malaysia, *International Journal of Management Excellence*, 5 (1): 584-590.

Ahmed, H. and Miller, S. M. (2000). Crowding-Out and Crowding-In Effects of the Components of Government Expenditure, *Contemporary Economic Policy*, 18: 124-33.

Alvarez, I. C., Barbero, J., Rodriguez-Pose, A. and Zofio, J. L. (2018). Does Institutional Quality Matter for Trade? Institutional Conditions in a Sectoral Trade Framework, *World Development*, 103: 72-87.

Anderson, J. E. (1979). A theoretical foundation for the gravity equation, *American Economic Review*, 69: 106-116.

Anderson, J., and Marcouiller, D. (2002). Insecurity and the pattern of trade: An empirical investigation, *Review of Economics and Statistics*, 84, 342–352.

Anderson, J. E., and van Wincoop, E. (2003). Gravity with Gravitas: A Solution to the Border Puzzle, *American Economic Review*, 93(1): 170–92.

Anderson, J. E., and van Wincoop, E. (2004). Trade costs. *Journal of Economic Literature, 42*, 691-751.

Ansar, A., Flyvbjerg, B., Budzier, A. and Lunn, D. (2016). Does Infrastructure Investment lead to Economic Growth or Economic Fragility? Evidence from China, *Oxford Review of Economic Policy,* 32(3): 360-390.

Apergis, N. (2000). Public and Private Investments in Greece: Complementary or 'Substitute' Goods?, *Bulletin of Economic Research,* 52:225-34.

Aschauer, D. (1989). Is Public Expenditure Productive? *Journal of Monetary Economics,* 23:177–200.

Auerbach, A. J. and Gorodnichenko, Y. (2012). Measuring the Output Responses to Fiscal Policy, *American Economic Journal*, 4(2): 1-27.

Aryeetey, E. and A. Oduro (1996). 'Regional Integration Efforts in Africa: An Overview', in J. J. Teunissen (ed). Regionalism and the Global Economy: The Case of Africa. The Hague: FONDAD.

Afesorgbor, S.K. and van Bergeijk , P.A.G (2005). Multi-membership and the Effectiveness of Regional Trade Agreements in Western and Southern Africa: A Comparative Study of ECOWAS and SADC." Institute of Social Sciences Working Paper No. 520. The Hague, The Netherlands

Badalyan, G., Herzfeld, T. and Rajcaniova, M. (2014). Transport Infrastructure and Economic Growth: Panel Data Approach for Armenia, Georgia and Turkey. Paper Prepared for Presentation for the 142nd EAAE Seminar Growing Success, Budapest, Hungary.

Bakar, N. A., Mat, S. H. and Harun, M (2012). The Impact of Infrastructure on FDI: The Caseof Malaysia, *Social and Behavioral Sciences*, 65: 205-211.

Balasubramanyam, V., Mohammed, S. and Sapsford, D. (1996). Foreign Direct Investment and Growth in EP and IS countries, *Economic Journal*,106: 92-105.

Baldwin, R., Forslid, R., Martin, P., Ottaviano, G. and Robert-Nicoud, F. (2003). *Economic Geography and Public Policy*, Princeton: Princeton University Press.

Baltagi, H. B. (2005). *Econometric Analysis of Panel Data* (Third Edition), Chichester, United Kingdom: Wiley.

Bangake, C. and Eggoh, J. C. (2012). Pooled Mean Group Estimation on International Capital Mobility in African Countries, *Research in Economics*, 66: 7-17.

Barro, R. J. (1978). Comments from an Unreconstructed Ricardian, *Journal of Monetary Economics*, 4: 569-581.

Barro, R. J. (1990). Government Spending in a Simple Model of Endogenous Growth. *Journal of Political Economy* 98, 103–125.

Barro, R. (1991). Economic Growth in Cross-Section of Countries, *Quarterly Journal of*

Economics, 106(2), 407-443.

Barro, R. J. (1995). Determinants of Economic Growth, MIT Press, London.

Barro, R. J. (1996). Determinants of Economic Growth: A Cross-Country Empirical Study, National Bureau of Economic Research Working Paper 5698, Cambridge.

Beaudry, P., Mustafa, C. and Fabio, S. (2001). Monetary Instability, the Predictability of Prices, and the Allocation of Investment: An Empirical Investigation using U.K. Panel Data, *American Economic Review*,91: 648-62.

Beck, S. E. (1993). The Ricardian Equivalence Proposition: Evidence from Foreign Exchange Markets, *Journal of International Money and Finance*, 12: 154-169.

Bende-Nabende, A. and Slater, J. (2003). Private Capital Formation: Short- and Long-run Crowding-in (out) Effects in ASEAN. *Economics Bulletin*, 3 (27): 1 – 16.

Bensassi, S., Marquez-Ramos, L., Martinez-Zarzoso, I. and Suarez-Burguet, C. (2014). Relationship between Logistics Infrastructure and Trade: Evidence from Spanish Regional Exports, *Transportation Research Part A*, 72: 47-61.

Behar, A. and P, Manners (2008). "Logistics and Exports", *Mimeo, CSAE*: Oxford.

Bergeijk and Brakman (2010). The Gravity Model of International Trade: Advances and Applications, Cambridge University Press.

Beverelli, C., Keck, A. Larch, M. and Yotov, Y. V. (2018). Institutions, Trade and Development: A Quantitative Analysis. CESifo Working Paper No. 6920, Munich, Germany.

Bhattacharya, A. Oppenheim, J. and Stern, N. (2015). Driving Sustainable Development Through Better Infrastructure: Key Elements of a Transformation Program, Global Economy and Development, Working Paper 91.

Bibi, S., Khan, U. A., and Bibi, A. (2012). Determinants of Investment in Pakistan. *Academic Research International*, *2* (2): 517-524.

Biehl, D. (1991). *"The Role of Infrastructure in Regional Development",* in Vickerman, R.W.(ed.), Infrastructure and Regional Development. Pion, London, UK.

de Jong, E. and Bogmans, C. (2010). Does Corruption discourage International Trade?, *European Journal of Political Economy,* 27: 385-398.

Boopen, S., and Khadaroo, A. J. (2009). Transportation Capital and Private Capital Formation in Mauritius: Testing the Substitutability and Complementarity Hypotheses. University of Mauritius. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.410.4424&rep=rep1&type=pdf

Bougheas, S., Demetriades, P., and Morgenroth, E. (1999). Infrastructure, Transport Costs and Trade, *Journal of International Economics* 47: 169-189.

Breitung, J., (2000). The local power of some unit root tests for panel data, *Advances in Econometrics,*15: 161–177.

Breusch, T.S. and Pagan, A.R. (1980). The Lagrange Multiplier Test and its Applications to Model Specification in Econometrics, *Review of Economic Studies,* 47: 239–253.

Burger, M., F. v. Oort, and G. Linders (2009). On the Specification of the Gravity Model of Trade: Zeros, Excess Zeros and Zero-inflated Estimation. Research Paper ERS-2009-003-ORG, Erasmus Research Institute of Management (ERIM).

Calderon, C. and Serven, L. (2002). The Output Cost of Latin America's Infrastructure Gap, Working Paper No. 186, Central Bank of Chile.

Calderon, C. (2009). Infrastructure and Growth in Africa. *World Bank Policy Research Working Paper Series*. No. 4914. African Sustainable Development Front Office.

Calderon, C. and Serven, L. (2010). Infrastructure in Latin America, Policy Research Working Paper No. 5317, World Bank, Washington D.C.

Calderon, C., Moral-Benito, E. and Serven, L. (2011). Is Infrastructure Capital Productive? A Dynamic Heterogeneous Approach, Policy Research Working Paper 5682, World Bank.

Chang, R.,Kaltani, L. and Loayza, N. (2005). Openness can be good for Growth: The Role of Policy Complementarities, *World Bank Policy Research Working Paper,* No. 3763.

Canning, D. and Pedroni, P. (1999). Infrastructure and Long Run Economic Growth, Centre for Analytical Economics Working Paper No. 99-09, Cornell University.

Canning, D. and Pedroni, P. (2004). The Effect of Infrastructure on Long Run Economic Growth. Mimeo, Williams College.

Cavallo, E., and Daude, C. (2011). Public Investment in Developing Countries: A Blessing or a Curse? *Journal of Comparative Economics, 39*(1), 65−81.

Celbis, M. G., Nijkamp, P. And Jacques, P. (2014). Infrastructure and Trade: A Meta – Analysis, *The Journal of ERSA,* 1(1): 25-65.

Chakamera, C. and Alagidede, P. (2017). The Nexus between Infrastructure (quantity and quality) and Economic Growth in Sub Saharan Africa, ERSA Working Paper 673.

Chi, J. and Baek, J. (2013). Dynamic Relationship between Air Transport Demand and Economic Growth in the United States: A New Look, *Transport Policy*, 29: 257-260.

Chirinko, S., (1993). Business Fixed Investment Spending: A Critical Survey of Modeling Strategies, Empirical Results, and Policy Implications. *Journal of Economic Literature*, 31, 1875-911.

Choi, I. (2001). Unit Root Tests for Panel Data, *Journal of International of Money and Finance*, 20, 249-272.

Clark, X., Dollar, D., and Micco, A. (2004). Port Efficiency, Maritime Transport Costs, and Bilateral Trade, *Journal of Development Economics*, 75 (2): 417–450.

Cosar, A. K. and Demir, B. (2015). Domestic Road Infrastructure and International Trade: Evidence from Turkey, *Journal of Development Economics*, 118: 232-244.

Crescenzi, R. and Rodriguez-Pose, A. (2012). Infrastructure and Regional Growth in the European Union, *Papers in Regional Science*, 91(3):487-513.

Davo, F., Alessandrini, S., Sperati, S., Monache, L. D., Airoldi, D. and Vespucci, M. T. (2016). Post-Processing Techniques and Principal Components Analysis for Regional Wind Power and Solar Irradiance Forecasting. *Solar Energy*. 134: 327-338.

De, P. (2006). Trade, Infrastructure and Transaction Costs: The Imperatives for Asian Economic Cooperation, *Journal of Economic Integration*, 21(4): 708-735.

Demurger, S. (2001). Infrastructure Development and Economic Growth: An Explanation for Regional Disparities in China? *Journal of Comparative Economics*, 29(1): 95–117.

Dixit, A. and Pindyck, R. S. (1994). *Investment under uncertainty*. Princeton, NJ: Princeton University Press.

Djankov, S., Freund, C. L. and Pham, C. S. (2006). "Trading on Time", *World Bank Policy Research Working Paper* No. 3909, the World Bank.

Domar, E. D. (1946). Capital Expansion, Rate of Growth, and Employment. *Econometrica*, Vol. 12 (2): 137 – 147.

Dong, X. (2006). The Analysis of the Effect of Government Expenditure on the Private Investment, *Chinese Contemporary Economic Research Journal*, 5: 65–68.

Drukker, D. M. (2003). Testing for Serial Correlation in Linear Panel-Data Models, *The Stata Journal*, Vol. 3(2), 168-177.

Duggal, V., Saltzman, C. and Klein, L. (1999). Infrastructure and Productivity: A Nonlinear Approach, *Journal of Econometrics*, 92(1): 47–74.

EAC, (1999). The Treaty for the Establishment of the East African Community, Arusha, Tanzania.

EAC, (2011a). 4TH EAC Development Strategy, 2011/12-2015/16. Arusha, Tanzania.

EAC, (2011b). East African Trade and Transport Facilitation Project: Final Report Arusha, EAC Secretariat.

Engle, R.F. and Granger, C.W.J. (1987). Co-integration and Error Correction: Representation, Estimation, and Testing, *Econometrica*, 55: 251–276.

Erden, L. and Holcombe, R. G. (2005). The Effects of Public Investment in Developing Economies, *Public Finance Review*, 33(5): 575-602.

Everhart, S. and Sumlinski, M. A. (2001). The Impact on Private Investment of Corruption and the Quality of Public Investment, Discussion Paper No. 44, International Finance Corporation.

Farhadi, M. (2015). Transport Infrastructure and Long-run Economic Growth in OECD Countries, *Transportation Research Part A*, 74: 73-90.

Fedderke, J. Perkins, P. and Luiz, J. (2006). Infrastructural Investment in Long-run Economic Growth: South Africa 1875-2001, *World Development* 34(6): 1037-1059.

Fedderke, J. and Garlick, R. (2008). Infrastructure Development and Economic Growth in South Africa: A Review of Accumulated Evidence, Policy Paper No. 12.

Fidrmuc, J. and Fidrmuc, J. (2016). Foreign Languages and Trade: Evidence from a Natural Experiment, *Empirical Economics*, 50: 31-49.

Fink, C., A. Mattoo, A., and Neagu, I.C. (2005). Assessing the Impact of Communication Costs on International Trade, *Journal of International Economics*, Vol. 67(2), 428-445.

Fisher, R. A. (1932). Statistical Methods for Research Workers, Oliver and Boyd, Edinburgh, 4th Edition.

Fourie, J. (2006). Economic Infrastructure in South Africa: A Review of Definitions, Theory and Empirics, *South African Journal Economics*, 95(4): 530-556.

Francois, J., and Manchin, M. (2006). Institutional *Quality, Infrastructure, and the Propensity to Export*, CEPR, London.

Francois, J., and Manchin, M. (2013). Institutions, Infrastructure, and Trade, *World Development*, 46: 165-175.

Frankel, J. (1997). 'Regional Trading Blocs in the World Economic System', Institute for International Economics, Washington D.C.

Froot, K. and Stein, J. (1991), Exchange Rate and Foreign Direct Investment: An Imperfect Capital Market Approach, *Quarterly Journal ofEconomics*,106: 1197-217.

Fuente, D., and Domenech, R. (2000). Human Capital in Growth Regressions: How Much Difference Does Data Quality Make? Economics Department Working Paper, 262, OECD, Paris.

Freund, C. and Rocha, N. (2011). What Constrains Africa's Exports? World Bank Policy Research Working Paper 5184. World Bank Economic Review.

Gallup, J. L, Sachs, J. and Mellinger, A. D. (1998). Geography and Economic Growth, Paper prepared for the Annual Bank Conference on Development Economics, Washington, D.D.

Garcia, V. A., Meseguer, J. A., Ortiz, L. P. and Tuesta, D. (2017). Infrastructure and Economic Growth from a Meta-Analysis Approach: Do all Roads Lead to Rome? BBVA Working Paper No. 17/07, Madrid, Spain.

German-Soto, V. and Bustillos, H.A. (2014). The Nexus between Infrastructure Investment and Economic Growth in the Mexican Urban Areas, *Modern Economy*, 5: 1208-1220.

Ghura, D. and Goodwin, B. (2000). Determinants of Private Investment: A Cross-Regional Empirical Investigation, *Applied Economics*, 32: 1819-29.

Gil-Pareja, S., Llorca-Vivero, R. and Martinez-Serrano, J. A. (2019). Corruption and International Trade: a Comprehensive Analysis with Gravity, *Applied Economic Analysis*, 27(49): 3-20

Gjini, A. and Kukeli, A. (2012). Crowding-Out Effect of Public Investment on Private Investment: An Empirical Investigation, *Journal of Business and Economics Research*, 10(5): 269-276.

Goldsmith, A. H. (2008). Rethinking the Relation between Government Spending and Economic Growth: A Composition Approach to Fiscal Policy for Principle Students, *Journal of Economic Education*, 39(2): 153-173.

Gramlich, E.M. (1994). Infrastructure Investment: A Review Essay, *Journal of Economic Literature*, 32(3): 1176-1196.

Grossman, G.M. and Helpman, E., (1991). "*Innovation and Growth in Global Economy*", MIT Press, Cambridge.

Grigoriou, C. (2007). Landlockedness, Infrastructure and Trade: New Estimates for Central Asian Countries. Policy Research Working Paper Series 4335, The World Bank, Washington DC.

Hall, R. E. and Jones, C. I. (1999). Why Do Some Countries Produce So Much More Output Per Worker Than Others?, *The Quarterly Journal of Economics*, 114(1): 83-116.

Hausman, J. A. (1978). Specification Tests in Econometrics, *Econometrica,* 46, 1251-1271.

Hadri, K. (2000). Testing for Stationarity in Heterogeneous Panel Data, *Econometrics*

Journal, 3: 148–161.

Hartman, R. (1972). The Effects of Price and Cost Uncertainty on Investment, *Journal of Economic Theory,* 5(2): 258– 66.

Head, K., and T. Mayer (2000). Non-Europe: The Magnitude and Causes of Market Fragmentation in the EU, Weltwirtschaftliches Archive 136 (2): 285-314.

Head, K., and Mayer, T. (2004). The Empirics of Agglomeration and Trade. In J. V. Henderson and Thisse, J.F. (Eds.), *The handbook of regional and urban economics* (Vol. 4, Cities and geography, pp. 2609-2665). Amsterdam: North Holland.

Henckel, T. and McKibbin, W. (2010). The Economics of Infrastructure in a Globalized World: Issues, Lessons and Future Challenges, The Brookings Institution.

Hernandez, J. and Taningco, A. B. (2010). Behind the Border Determinants of Bilateral Trade Flows in East Asia, ARTNeT Working Paper Series, No. 80.

Holtz-Eakin, D. (1993). Solow and the States. Capital Accumulation, Productivity, and Economic Growth. *National Tax Journal*, 46 (4): 425-439.

Huang, Q. and Harata N. (2010). Role of Infrastructure in Economic Development. An Empirical Study for China, *Transportation Studies*. 166-173.

Hulten, C.R., Bennathan, E. and Srinivasan, S. (2005). Infrastructure, Externalities, and Economic Development: A Study of Indian Manufacturing Industry, Mimeo, World Bank, Washington DC.

Husted, S. and Melvin, M. (2007). *International Economics* (Seventh Edition), Boston, Pearson-Addison-Wesley.

Im, K.S., Pesaran, H.M. and Shin, Y. (2003). Testing for Unit Roots in Heterogeneous Panels, *Journal of Econometrics*, 115(1): 53-74.

International Monetary Fund (2015). Monitoring and Managing Fiscal Risks in the East African Community, Washington, D.C.

International Monetary Fund (2016). Regional Economic Outlook: Sub-Saharan Africa-Multispeed Growth, Washington, D.C.

Ismail, N. W. and Mahyideen, J. M. (2015). The Impact of Infrastructure on Trade and Economic Growth in Selected Economies in Asia. Asian Development Institute, Working Paper 553.

Jacks, D. S., Meisnner, C. M. and Novy, D. (2008). Trade Costs, 1870-2000, *American Economic Review*, Vol. 98(2): 529-534.

Jansem, M. and Nordas, H. K. (2004). Institutions, Trade Policy and Trade Flows, World Trade Organization Staff Working Paper ERSD No. 2004-02.

Jerome, A. (2011). Infrastructure, Economic Growth and Poverty Reduction in Africa. The Secretariat, Nigeria Governors' Forum, Abuja, Nigeria.

Jorgenson, D. (1963). Capital Theory and Investment Behaviour. *American Economic Review* 53: 247-59.

Jouanjean, M-A. Gachassin, M. and Velde, D. W. (2016). Regional Infrastructure for Trade Facilitation-Impact on Growth and Poverty Reduction, Overseas Development Institute, London.

Kao, C. (1999). Spurious Regression and Residual-based Tests for Cointegration in Panel Data, *Journal of Econometrics,* 90: 1-44.

Kenny, C. (2009). Measuring Corruption in Infrastructure: Evidence from Transition and Developing Countries, *Journal of Development Studies,* 45(3): 314–332.

Keynes, J. M. (1936). 'The General Theory of Employment, Interest and Money', Macmillan, London.

Kimenyi, M.S., Mwega, F. M. and Ndung'u, N. S (2016). The African Lions: Kenya Country Case Study, The Brookings Institution.

King, R. G. and Rebelo, S. T. (1993). Transitional Dynamics and Economic Growth in Neoclassical Model, *The American Economic Review,* 83 (4): 908-931.

Kodongo, O. and Ojah, K. (2016). Does Infrastructure Really Explain Economic Growth in SSA, *Review of Development Finance*, 6: 105-125.

Krugman, P. (1994). The Myth of Asia's Miracle, *Foreign Affairs*, 73: 62-78.

Krugman, P. (1979). Increasing Returns, Monopolistic Competition, and International Trade, in Krugman, P. (Ed), *Rethinking International Trade* (6th edition), Cambridge, Massachusetts Institute of Technology.

Krugman, P. (1980). Scale Economies, Product Differentiation, and the Pattern of Trade, in Krugman, P. (Ed), *Rethinking International Trade* (6th edition), Cambridge, Massachusetts Institute of Technology.

Kustepeli, Y. (2005). Effectiveness of Fiscal Spending: Crowding Out and/or Crowding In? *Yönetimve Ekonimi*, 12(1): 185-192.

Kustepeli, Y., Gulcan,Y. and Akgungor, S. (2012). Transportation Infrastructure Investment, Growth and International Trade in Turkey, *Applied Economics,* 44(20): 2619-2629.

Larch, M., Monteiro, J-A., Peirmartini, R. and Yotov, Y. V. (2019). On the Effects of GATT/WTO Membership on Trade: They are Positive and Large After All. WTO Staff Working Paper ERSD-2019-09.

Levchenko, A. (2007). Institutional quality and international trade. *Review of Economic Studies*, 74(3), 791–819.

Levin, A., Lin, C.F., and Chu, C-S.J. (2002). Unit Root Tests in Panel Data: Asymptotic and Finite Sample Properties, *Journal of Econometrics*, 108(1): 1–22.

Lewis, B.D. (1998). The Impact of Public Infrastructure on Municipal Economic Development: Empirical Results from Kenya. *Review of Urban and Regional Development Studies*, 10(2): 142-155.

Limam, Y. R. and Miller, S. M. (2004). Explaining Economic Growth: Factor Accumulation, Total Factor Productivity Growth, and Production Efficiency Improvement, University of Connecticut Working Paper 2004 – 20.

Limao, N. and Venables, A. J. (1999). Infrastructure, Geographical Disadvantage, and Transport Costs, Policy Research Working Paper 2257, World Bank.

Limao, N. and Venables, A. J. (2001). Infrastructure, Geographical Disadvantage, Transport Costs and Trade, *World Bank Economic Review*, 15: 451-479.

Lin, J., Flachsbarth, I. and von Cramon-Taubadel, S. (2019). The Role of Institutional Quality on the Performance in the Export of Coconut Products, *Agricultural Economics,* 51: 237-258.

Longo, R, and Sekkat, K (2004). Economic Obstacles to Expanding Intra-African Trade. *World Development*, 32: 1309-1321.

Loungani, P. and Rush, M. (1995), The Effect of Changes in Reserve Requirements on Investment and GNP, *Journal of Money, Credit and Banking*, 27: 511-26.

Lund, M.T. (2010). *Foreign Direct Investment: Catalyst of Economic Growth?*, Doctorate Dissertation, Department of Economics, University of Utah.

Lynde, C. and Richmond, J. (1992). The Role of Public Capital in Production, *The Review of Economics and Statistics*, 74(1): 37-44.

Maddala, G.S., and Wu, S. (1999). A comparative Study of Unit Root Tests with Panel Data and a New Simple Test", *Oxford Bulletin of Economics and Statistics*, 61: 631-652

Marazzo, M., Scherre, R., and Fernandes, E. (2010). Air Transport Demand and Economic Growth in Brazil: A Time Series Analysis, *Transportation Research*, 46: 261-269.

Martincus, C. V. and Blyde, J. (2013). Shaky Roads and Trembling Exports: Assessing the Trade Effects of Domestic Infrastructure using a Natural Experiment, *Journal of International Economics*, 148-161.

Medeiros, V., Ribeiro, R. S. M. and do Amaral, P. V. M. (2020). Infrastructure and Household Poverty in Brazil: A Regional Approach using Multilevel Models, *World Development,* 137: 1-14.

Mbekeani, K. K. (2007). The Role of Infrastructure in Determining Export Competitiveness: Framework Paper.

McCulloch, R. (1989). Japanese Investment in the United States, in *The Internationalization of U.S. Markets*, New York , New York University Press.

McKinnon, R., I. (1973). Money and Capital in Economic Development. Washington, DC: The Brookings Institution.

Melo, P. C., Graham, D. J. and Brage-Ardao, R. (2013). The Productivity of Transport Infrastructure Investment: A Meta of Empirical Evidence, *Regional Science and Urban Economics*, 43: 695-706.

Micco, A. and Serebrisky, T. (2004). Infrastructure, Competition Regimes, and Air Transport Costs: Cross-Country Evidence. Policy Research Working Paper Series 3355, World Bank. Washington.

Moosa, I.A. (2012). The Determinants of Foreign Direct Investment in MENA Countries: An Extreme Bounds Analysis, *Research Report 0421*. Department of Economics and Finance, La Trobe University. Chicago, Illinois: University of Chicago Press.

Mora-Rivera, J. and Garcia-Mora, F. (2021). Internet Access and Poverty Reduction: Evidence from Rural and Urban Mexico, *Telecommunications Policy*, 45: 1-22.

Narayan, P. K. (2004). Do Public Investments Crowd Out Private Investments? Fresh Evidence from Fiji, *Journal of Policy Modeling*, 26: 747-53.

Nelson, R. R., and Phelps, E. S. (1966). Investment in Human, Technological Diffusion, and Economic Growth, *American Economic Review*, 56: 69-75.

Nordas, H., and Piermartini, R.j. (2004). Infrastructure and Trade: World Trade Organization Economic Research and Statistics Division Staff Working Paper ERSD-2004-04.

Orsal, D. D. K. (2008). Comparison of Panel Cointegration Tests. *Economics Bulletin*, 3: 1-20.

Pedroni, P.L. (2004). Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests with an Application to the Purchasing Power Parity Hypothesis, *Econometric Theory*, 20: 597-625.

Pereira, A. M. (2000). Is all Public Capital Created Equal?, *Review of Economics and Statistics*, 82: 513-18.

Pesaran, M.H. (2004). General Diagnostic Tests for Cross Section Dependence in Panels;

CESifo Working Papers No. 1233: 255–260, Munchen, Germany.

Pesaran, M.H., Shin, Y., and Smith, R.P. (1999). Pooled Mean Group Estimation of Dynamic Heterogeneous Panels, *Journal of American Statistical Association*, 94: 621-634.

Portugal-Perez, A., and Wilson, J. S. (2012). Export Performance and Trade Facilitation Reform: Hard and Soft Infrastructure. *World Development*, 40(7): 1295–1307.

Pradhan, R. P. and Bagchi, T. P. (2013). Effect of Transportation Infrastructure on Economic Growth in India: The VECM Approach, *Research in Transportation Economics*, 38: 139-148.

Pritchett, L. (1996). Mind Your P's and Q's. The Cost of Public Investment is not the Value of Public Capital. Policy Research Working Paper 1660, World Bank, Washington, DC.

Pritchett, L. (2000). The Tyranny of Concepts: CUDIE (Cumulated, Depreciated, Investment Effort) Is Not Capital, *Journal of Economic Growth*, 5 (4): 361–84.

Ramirez, M. D. (1994). Public and Private Investment in Mexico, 1950-90: An Empirical Analysis. *Southern Economic Journal*,61 (1): 1-17.

Ramirez, M. D. (2000). The Impact of Public Investment on Private Investment Spending in Latin America: 1980-95, *Atlantic Economic Journal*, 28: 210-25.

Rehman, A., Ilyas, M. and Alam, H. M. (2011). The Impact of Infrastructure on Foreign Direct Investment: The Case of Pakistan, *International Journal of Business and Management*, 6 (5): 268-276.

Roller, L. H and Waverman, L. (1996). Telecommunications Infrastructure and Economic Development: A simultaneous Approach, Discussion Paper FS IV 96-16, Wissenschaftszentrum, Berlin.

Romer, P. (1990). Endogenous technological change. *Journal of Political Economy*, 98, 5(2): S71-S102.

Romer, P.M. (1987). Crazy Explanations for Productivity Slowdown, in S. Fischer, ed., *NBER Macroeconomics Annual*, MIT Press, Cambridge, 163-202.

Romp, P and J de Haan, (2005). Public Capital and Economic Growth: A critical Survey, *European Investment Bank Papers*. Vol. 10 N 1.

Rose, A. K. (2004). Do we Really know that the WTO Increases Trade?, *American Economic Review*, 94(1): 98-114.

Roy, J. (2011). Is the WTO Mystery Really Solved?, *Economics Letters*, 113(2): 127–130.

Saidi, S. and Hammami, S. (2017). Impact of Investments in Public Infrastructures on

Economic Performance and Private Investment in Developing Countries: A Case Study for Tunisia, *The Romanian Economic Journal*, 63: 126-146.

Sahoo, P., Dash, R. K. and Nataraj, G. (2010). Infrastructure Development and Economic Growth in China, Institute of Developing Economies, Discussion Paper no. 261, Jetro.

Sahoo, P., Dash, R. K. and Nataraj, G. (2012). China's Growth Story: The Role of Physical and Social Infrastructure, *Journal of Economic Development*, 37(1): 53-75.

Salmon, M. (1982). Error Correction Mechanisms. *Economic Journal*,92:615-29.

Samuelson, P.A. (1954). The Transfer Problem and Transport Costs, II: Analysis of Effects of Trade Impediments. *The Economic Journal, 64*(254), 264-289.

Santos Silva, J. and S. Tenreyro (2006). The Log of Gravity, *The Review of Economics and Statistics,* 88: 641-58.

Schmieg, E. (2016). Global Trade and African Countries: Free Trade Agreements, WTO and Regional Integration, SWP Working Paper RD EU/Europe, Berlin.

Serebrisky, T., Suarez-Aleman, A., Margot, D. and Ramirez, M. C. (2015). Financing Infrastructure in Latin America and the Caribbean: How, How much and by Whom?, IDB, Washington, DC, USA.

Serven, L. and Solimano. A., (1993). Economic Adjustment and Investment Performance in Developing Countries: The Experience of the 1980s, in *Striving for Structural Adjustment: The Role of Capital Formation* by Serven, L. and A. Solimano, Eds., The World Bank: Washington D.C., 147-180.

Serven, L. (1996). Does Public Capital Crowd Out Private Capital? Evidence from India. Working paper, The World Bank.

Serven, L. (2002). Real Exchange Rate Uncertainty and Private Investment in Developing Countries, Domestic Finance Working Paper 2823, World Bank, Washington, DC.

Shah, M. H. (2014). The Significance of Infrastructure for FDI Inflow in Developing Countries, *Journal of Life Economics,* 2: 1-16.

Shaw E. (1973). Financial Deepening in Economic Development. New York: Oxford University Press.

Shepherd, B. and Wilson J. S. (2009). Trade Facilitation in ASEAN Member Countries: Measuring Progress and Assessing Priorities, *Journal of Asian Economics,* 20(4): 367-383.

Shinyekwa, I. M. B. and Ntale, N. (2017). The Role of Economic Infrastructure in Promoting Exports of Manufactured Products: Trade Facilitation and Industrialization in the EAC, Economic Policy Research Centre, Research Series No. 139.

Silva, J. S. and S. Tenreyro (2009). Further Simulation Evidence on the Performance of the Poisson Pseudo-Maximum Likelihood Estimator. Economics Discussion Papers 666, University of Essex, Department of Economics.

Soloaga, I., Wilson, J.S. and Mejia, A. (2006), Moving Forward Faster: Trade Facilitation Reform and Mexican Competitiveness, *World Bank Policy Research Working Paper No. 3953*.

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth, *Quarterly Journal of Economics*, 70 (1), 65–94.

Straub, S. (2008). Infrastructure and Growth in Developing Countries: Recent Advances and Research Challenges, *World Bank Policy Research Working Paper Series.* No. 4460. Washington, DC: World Bank.

Straub, S. (2011). Infrastructure and Development: A Critical Appraisal of the Macro-Level Literature, *The Journal of Development Studies*, 47(5): 683-708.

Straub, S. Vellutini, C. and Warlters, M. (2008). Infrastructure and Economic Growth in East Asia, Policy Research Working Paper 4589, World Bank.

Straub, S. and Terada-Hagiwara, A. (2011). Infrastructure and Growth in Developing Asia, *Asian Development Review,* 28(1): 119-156.

Stupak, J. M. (2018). Economic Impact of Infrastructure Investment, CRS Report, R 44896, Congressional Research Service.

Suhendra, I. and Anwar, C. J. (2014). Determinants of Private Investment and the Effects on Economic Growth in Indonesia, *GSTF International Journal of Business Review,* 3(3), 1-6.

Tinbergen, J. (1962). *Shaping the World Economy: Suggestions for an International Economic Policy*. New York: The Twentieth Century Fund.

Turkson, F. E. (2012). Trade Agreements and Bilateral Trade in Sub-Saharan Africa: Estimating the Trade Effects of the EU-ACP PTA and RTAs, CREDIT Research Paper No. 12/7, University of Nottingham.

Turnovsky, Stephen J., (1996). Fiscal Policy, Adjustment Costs, and Endogenous Growth, *Oxford Economic Papers*, 48, 361-81.

UNCTAD (2006). Review of Maritime Transport. United Nations, New York and Geneva.

UNCTAD (2013). Supporting Infrastructure Development to Promote Economic Integration: The Role of Public and Private Sectors, UNCTAD Secretariat, Geneva, Switzerland.

UNCTAD (2015). Review of Maritime Transport 2015, United Nations, New York and Geneva.

Unglert, K., Radic, V. and Jellinek, A. M. (2016). Principal Component Analysis vs. Self-Organizing Maps Combined with Hierarchical Clustering for Pattern Recognition in Volcano Seismic Spectra. *Journal of Volcanology and Geothermal Research*. 320: 58-74.

United Nations Industrial Development Organization (2016). The 2030 Agenda for Sustainable Development: Achieving the Industry-Related Goals and Targets, Vienna, Austria.

United States International Trade Commission (2009). Sub-Saharan Africa: Effects of Infrastructure Conditions on Export Competitiveness, United States International Trade Commission, Third Annual Report, Investigation No. 332-477.

Voss M. G. (2002). Public and Private Investment in the United States and Canada, *Economic Modeling*, 19: 641-664.

Wekesa, C. T., Wawire, N. H., and Kosimbei, G. (2017). Effects of Infrastructure Development on Foreign Direct Investment in Kenya, *Journal of Infrastructure Development*, 8 (2): 93-110.

Wilson, J. S., Mann, C. L. And Otsuki, T. (2003). Trade Facilitation and Economic Development: A New Approach to Quantifying the Impact, *The World Bank Economic Review*, 17 (3): 367-389.

Wilson, J. S., Mann, C. L., and Otsuki, T. (2005). Assessing the Benefits of Trade Facilitation: A Global Perspective. *World Economy*, 28, 841–871.

Wilson, J.S., Njinkeu, D. and Fosso, B.P. (2008). Expanding Trade within Africa: The Impact of Trade Facilitation", *Policy Research Paper* 4790, The World Bank Development Research Group.

Wooldridge, J. M. (2002). *Econometric Analysis of Cross Section and Panel Data*, MIT Press, Cambridge, MA.

World Bank, (2016). World Development Indicators.

World Bank (2017) Africa's Pulse, April 2017, Volume 15, Washington DC.

World Trade Organization, (2004). World Trade Report 2004: Exploring Linkage between the Domestic Policy Environment and International Trade, Geneva, Switzerland.

World Trade Organization, (2015). Aid for Trade at a Glance 2015: Reducing Trade Costs for Inclusive, Sustainable Growth, OECD, WTO.

Xu, X. and Yan, Y. (2014). Does Government Investment Crowd out Private Investment in China? *Journal of Economic Policy Reform*, 17(1): 1-12.

Yu, N., Jong, M., Storm, S. and Mi, J. (2012). The Growth Impact of Transport Infrastructure

Investment: A regional Analysis for China (1978-2008), *Policy and Society*, 31(1): 25-38.

Yu, S., Beugelsdijk, S., and de Haan, J. (2015). Trade, Trust and the Rule of Law, *European Journal of Political Economy*, 37: 102–115.

http://dataportal.opendataforafrica.org/bbkawjf/afdb-socio-economic-database-1960-2019. Accessed on 16/08/2020

https://databank.worldbank.org/source/world-development-indicators. Accessed on 16/08/2020

APPENDIX

APPENDIX A: Perpetual Inventory Method

Capital stock is not readily available for most countries as the case of EAC. In this case, the study uses time series data from the World Bank's WDI to construct an appropriate proxy for the capital stock levels.

To construct capital stock series data, the study used "Perpetual Inventory Method" which is given by the formula:

$$K_t = K_{t-1} - \delta K_{t-1} + GFK_t = (1-\delta)K_{t-1} + GFK_t \quad \text{(A1)}$$

Where: K_t –is the time t level of capital stock.

GFK_t – is the level of GFCF at time t.

δ- is the rate of depreciation, which is assumed to be constant over time. Limam and Miller (2004) suggest a depreciation rate of capital stock as 0.06, this rate widely accepted and hence adopted in this study.

In order to come up with the capital stock series, the following are required:

i. A time series on GFCF (in constant local currency units or US $).
ii. An estimate of the rate of depreciation of the existing capital stock.
iii. An estimate of the initial level stock of capital.

Following Hall and Jones (1999), the initial capital stock can be approximated by following formula:

$$K_0 = \frac{GFK_0}{\delta + g_{GFK}} \quad \text{(A2)}$$

Where: K_0-is the initial capital stock, for this study, this is capital stock in 1990.

GFKo- is the level of GFCF in the initial period, which is 1990.

g_{GFK} -is the rate of growth of GFCF. Fuente and Domenech (2000) use the average growth rate of the first 10 observations as proxy for the growth rate of investments which is adopted in this study.

δ -the rate of depreciation of the existing capital stock, which is 6 percent.

Therefore, given equations A1 and A2 and the value of δ as 0.06 and a time series data on GFCF, then a capital stock series can be constructed. That is, after calculating the initial capital stock (K_{1990}) for all the countries, the capital stock for the year 1991 (K_{1991}) is calculated as:

$$K_{1991} = K_{1991-1} - \delta K_{1991-1} + GFK_{1991} = (1-\delta)K_{1991-1} + GFK_{1991}$$

$$K_{1991} = (1-\delta)K_{1990} + GFK_{1991} \quad (A3)$$

APPENDIX B: Aggregate Infrastructure Indexes in EAC, 1990-2019

The values in Figure B1 are computed from the first infrastructure stock index which is composed of paved roads, electricity generating capacity and main telephone lines per 1000 workers.

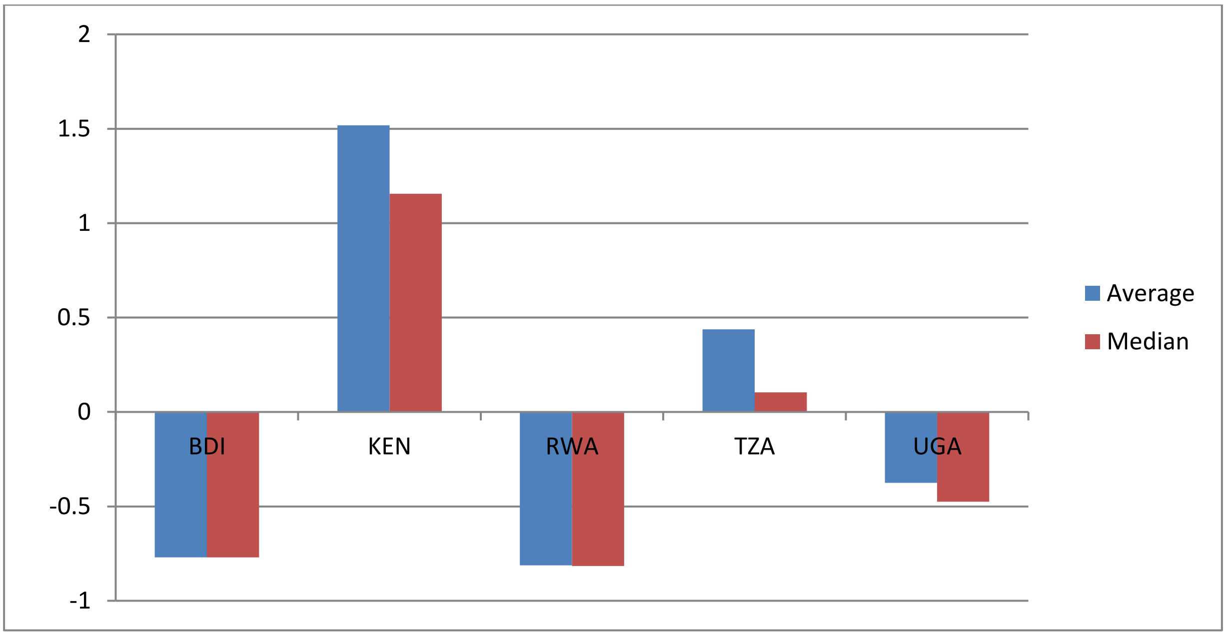

Figure B1: First Infrastructure Stock in EAC, 1990-2019

Note: BDI-Burundi, KEN-Kenya, RWA-Rwanda, TZA-Tanzania and UGA-Uganda

The values in Figure B2 are computed from the second infrastructure index which is composed of total road and railway network in a country, electricity generating capacity and main telephone lines and mobile phone subscriptions per 1000 workers

Figure B2: Second Infrastructure Stock in EAC, 1990-2019

Note: BDI-Burundi, KEN-Kenya, RWA-Rwanda, TZA-Tanzania and UGA-Uganda

APPENDIX C: Cointegration Test Results

Table C1: Westerlund Cointegration Test Results

Statistic	Value	Z-Value	P-Value
Gt	-3.472	-2.156**	0.014
Ga	-16.991	-1.914**	0.027
Pt	-5.469	-2.245**	0.012
Pa	-17.507	-6.687***	0.000

*Note: *** and ** Indicate that parameter is significant at 1 percent and 5 percent respectively*

Table C1: Johansen Fisher Cointegration Test Results

Model	Fisher Statistic (from trace test)	P-Value	Fisher Statistic (from max-eigen test)	P-Value
None	123.8	0.00	61.56	0.00
At most 1	75.44	0.00	46.92	0.00
At most 2	42.26	0.34	35.30	0.41
At most 3	28.41	0.57	24.81	0.57

APPENDIX D: Hausman Test for Homogeneity of Long-run Parameters

Table D1: Hausman Test Results

	MG(A)	PMG(B)	Difference(A-B)	S.E
LK	0.2058	0.1697	0.0361	0.2108
LL	-0.6397	-1.7593	1.1196	0.7642
INFRA	0.0583	0.7601	-0.7018	0.6705

$\chi^2(3) = 3.58 P - Value = 0.6117$

APPENDIX E: Infrastructure Investment and Private Investment

Table E1: Descriptive Statistics for Individual Countries

	BDI		KEN		RWA		TZA		UGA	
Variable	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**
PVI	6.4	2.8	10.0	2.4	6.5	2.8	16.3	4.8	11.1	5.6
PBI	3.5	2.9	4.6	2.6	6.4	2.8	5.5	4.0	4.8	3.4
RIR	4.2	6.6	8.5	7.3	8.7	6.6	6.0	5.2	11.9	7.7
ED	92.2	48.6	49.7	29.6	49.2	30.6	73.8	49.8	50.8	27.4
RDGP	1.8E+9	3.1E+8	3.3	1E+9	4.1E+9	2.2E+7	2.3+E10	1.1+E10	1.4+E10	7.1E+9
OP	36.4	9.7	55.8	7.8	37.3	10.6	47.2	8.8	39.5	8.7
RER	871.3	502.4	69.4	19.8	445.7	206.2	1032.7	542.4	1762.9	743.3
CRE	15.4	3.0	25.7	4.4	11.9	4.7	9.6	3.8	9.0	4.3
INF	11.2	8.0	12.5	9.9	7.5	4.9	13.2	9.7	10.0	11.5

Note: *The variables PVI, PBI, ED, OP and CRE have been expressed as a percentage of GDP. The descriptive summary statistics were based on 150 observations from 5 countries in EAC, from 1990-2019.*

Table E2: Johansen Fisher Panel Cointegration Test Results

Null Hypothesis: No cointegration

Model	Fisher Statistic (from trace test)	P-Value	Fisher Statistic (from max-eigen test)	P-Value
None	103.0	0.0000	70.44	0.0000
At most 1	45.61	0.0000	38.28	0.0000
At most 2	16.66	0.0823	9.956	0.4444
At most 3	12.27	0.2674	8.960	0.5359
At most 4	8.538	0.5764	7.875	0.6410
At most 5	11.49	0.3210	11.49	0.3210

APPENDIX F: INFRASTRUCTURE DEVELOPMENT AND TRADE

Table F1: Correlation Matrix for Transport Infrastructure Variables

	Paved Roads	Unpaved Roads	Railway
Paved Roads	1.000		
Unpaved Roads	0.8157	1.000	
Railway	0.8579	0.8557	1.000

Table F2: Eigenvalues for Transport Infrastructure Stock

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.6864	2.5021	0.8955	0.8955
Comp2	0.1843	0.0550	0.0614	0.9569
Comp3	0.1293	-	0.0431	1.000

The first principal component has an eigenvalue of 2.69, which is the largest and explains 90 percent of the total variance. The second and third principal components have eigenvalues of 0.18 and 0.12 and explain 6 and 4 percent of the total variance respectively.

Table F3: Eigenvectors for Transport Infrastructure Stock

Variable (in Logs)	Comp1	Comp2	Comp3
Paved Roads	0.5745	-0.6970	0.4291
Unpaved Roads	0.5740	-0.7168	0.3959
Railway	0.5835	-0.0188	-0.8119

From the first principal component, all the variables have almost equal weights. They enter with positive weights implying that all the variables are represented. The constructed index is given by the following equation:

$$TIS1_{it} = 0.57lnPR + 0.57lnUPR + 0.58lnRW \qquad (F1)$$

Where

$TIS1_{it} -$ is the index for transport infrastructure stock

$lnPR -$ is log of paved road network in kilometers

$lnUPR -$is log of unpaved road network in kilometers

$lnRW -$is log of railway network in kilometers

ICT INFRASTRUCTURE INDEX

Table F4: Correlation Matrix for ICT Infrastructure Variables

	Main telephone	**Mobile phones**	**Internet**
Main telephone	1.000		
Mobile phones	0.2451	1.000	
Internet	0.2720	0.7603	1.000

Table F5: Eigenvalues for ICT Infrastructure Stock

Component	**Eigenvalue**	**Difference**	**Proportion**	**Cumulative**
Comp1	1.9076	1.0544	0.6359	0.6359
Comp2	0.8532	0.6141	0.2844	0.9203
Comp3	0.2392	-	0.0797	1.000

Table F6: Eigenvectors for ICT Infrastructure Stock

Variable (in Logs)	Comp1	Comp2	Comp3
Main telephone	0.3737	0.9271	0.0283
Mobile phones	0.6528	-0.2846	0.7020
Internet	0.6589	-0.2439	-0.7116

The constructed index is given by the following equation:

$$ICTIS1_{it} = 0.37\ MT + 0.65\ MP + 0.66\ INT \qquad (F2)$$

Where

$ICTIS1 -$ is the index for ICT infrastructure stock

$MT -$is main telephones per 100 inhabitants

$MP -$is mobile phones per 100 inhabitants

$INT -$is internet subscribers per 100 inhabitants

Table F7: Descriptive Statistics for Burundi, 1990-2019

BURUNDI

Variable	Min.	Max.	Mean	Std. Dev	Skewness	Obs.
Exports (US$ Million)	0.014	32.28	3.83	4.89	2.97	120
GDP *i* (US$ Million)	785	3,170	1,700	859.00	0.72	120
GDP *j* (US$ Million)	1,380	87,900	20,700	19,100	1.50	120
Distance (weighted) Km	162.18	893.73	622.12	299.71	-.56	120
Population *i* (Million)	6.06	11.20	8.11	1.63	0.69	120
Population *j* (Million)	6.01	56.30	30.10	14.20	-0.33	120
Contiguity	0	1	0.50	0.50	0	120
Common Lang. Official	0	1	0.25	0.44	1.18	120
Common Lang. Ethnicity	0	1	0.25	0.44	1.18	120
Colonial Ties	0	1	0.25	0.44	1.18	120
Inflation	-2.81	31.11	11.50	8.67	0.89	120
REER	302.75	1,782.88	1,118.01	426.34	-0.40	120
Net FDI (US$ Million)	-11.44	117.00	11.90	29.4	2.52	120
Transport Infrastructure *i*	-1.07	-0.69	-0.79	0.06	0.35	120
Transport Infrastructure *j*	-0.91	3.08	0.28	1.05	0.67	120
ICT Infrastructure *i*	-0.89	0.34	-0.46	0.43	0.83	120
ICT Infrastructure *j*	-0.89	2.10	0.19	1.01	0.61	120
Corruption Index	-1.45	-0.68	-1.06	0.23	-.017	120
Free Trade Area	0	1	0.48	0.50	0.10	120

Table F8: Descriptive Statistics for Kenya, 1990-2019

KENYA

Variable	Min.	Max.	Mean	Std. Dev	Skewness	Obs.
Exports (US$ Million)	4665.88	654.71	203.04	187.12	1.01	120
GDP *i* (US$ Million)	12,000	65,400	35,700	23,600	0.58	120
GDP *j* (US$ Million)	785	58,000	12,200	13,800	1.88	120
Distance (weighted) Km	583.76	877.51	743.38	118.85	-0.05	120
Population *i* (Million)	28.60	48.46	39.20	7.00	0.20	120
Population *j* (Million)	6.01	56.30	22.32	15.20	0.49	120
Contiguity	0	1	0.50	0.50	0	120
Common Lang. Official	0	1	0.75	0.44	-1.18	120
Common Lang. Ethnic	0	1	0.75	0.44	-1.18	120
Colonial Ties	0	1	0.50	0.50	0	120
Inflation	1.96	26.24	9.01	4.77	1.86	120
REER	57.11	103.41	79.56	13.00	0.31	120
Net FDI (US$ Million)	5.30	1,630.00	426.00	515.00	1.32	120
Transport Infrastructure *i*	1.37	3.08	1.73	0.51	1.85	120
Transport Infrastructure *j*	-1.07	1.87	-0.33	0.69	1.58	120
ICT Infrastructure *i*	-0.89	1.95	0.43	1.19	0.32	120
ICT Infrastructure *j*	-0.89	2.10	-0.03	0.96	0.94	120
Corruption Index	-1.16	-0.85	-1.00	0.09	-0.07	120
Free Trade Area	0	1	0.64	0.48	-0.61	120

Table F9: Descriptive Statistics for Rwanda, 1990-2019

RWANDA

Variable	**Min.**	**Max.**	**Mean**	**Std. Dev**	**Skewness**	**Obs.**
Exports (US$ Million)	113.52	260.90	27.67	44.55	2.88	120
GDP *i* (US$ Million)	1,380	9,5100	4,650.00	2,870.00	0.50	120
GDP *j* (US$ Million)	785	87,900	20,000.00	19,700	1.39	120
Distance (weighted) Km	162.18	928.21	582.48	308.93	-0.21	120
Population *i* (Million)	6.01	12.30	9.36	1.72	-0.54	120
Population *j* (Million)	6.06	56.30	29.80	14.70	-0.38	120
Contiguity	0	1	0.75	0.44	-1.18	120
Common Lang. Official	1	1	1	0	-	120
Common Lang. Ethnic	0	1	0.75	0.44	-1.18	120
Colonial Ties	0	1	0.25	0.44	1.18	120
Inflation	-2.41	15.44	6.37	4.58	0.16	120
Real Effective Exc. Rate	301.53	861.09	555.50	157.37	-0.10	120
Net FDI (US$ Million)	1,500	3150.00	1,160.00	119.00	0.70	120
Transport Infrastructure *i*	-1.07	-0.77	-0.86	0.07	0.19	120
Transport Infrastructure *j*	-1.07	3.08	0.31	1.06	0.70	120
ICT Infrastructure *i*	-0.89	2.10	0.10	1.14	0.89	120
ICT Infrastructure *j*	-0.89	1.96	0.05	1.00	0.84	120
Corruption Index	-0.75	0.76	-0.04	0.55	0.28	120
Free Trade Area	0	1	0.64	0.48	-0.61	120

Table F10: Descriptive Statistics for Tanzania, 1990-2019

TANZANIA

Variable	**Min.**	**Max.**	**Mean**	**Std. Dev**	**Skewness**	**Obs.**
Exports (US$ Million)	0.53	793.89	82.04	134.00	3.84	120
GDP *i* (US$ Million)	6,500	58,000	27,800	7,618	0.84	120
GDP *j* (US$ Million)	785	65400	17,400	20,500.00	1.97	120
Distance (weighted) Km	658.66	950.22	857.70	117.37	-1.07	120
Population *i* (Million)	30.40	56.30	41.60	7.88	0.41	120
Population *j* (Million)	6.01	51.40	21.70	14.30	0.36	120
Contiguity	1	1	1	0	-	120
Common Lang. Official	0	1	0.75	0.44	-1.18	120
Common Lang. Ethnic	0	1	0.25	0.44	1.18	120
Colonial Ties	0	1	0.50	0.50	0	120
Inflation	3.49	20.98	8.45	4.48	0.82	120
Real Effective Exc. Rate	579.98	2.263.78	1,302.25	505.09	0.49	120
Net FDI (US$ Million)	150.01	2,087.26	875.00	566.00	0.45	120
Transport Infrastructure *i*	0.05	1.87	0.66	0.59	0.89	120
Transport Infrastructure *j*	-1.07	3.08	-0.07	1.10	1.29	120
ICT Infrastructure *i*	-0.89	1.62	0.18	1.02	0.44	120
ICT Infrastructure *j*	-0.89	1.92	0.03	1.03	0.96	120
Corruption Index	-0.81	-0.23	-0.62	0.17	0.87	120
Free Trade Area	0	1	0.64	0.48	-0.61	120

Table F11: Descriptive Statistics for Uganda, 1990-2019

UGANDA

Variable	Min.	Max.	Mean	Std. Dev	Skewness	Obs.
Exports (US$ Million)	0.94	580.15	88.62	115.67	1.90	120
GDP *i* (US$ Million)	5,840	27,500	14,800	8,440	1.11	120
GDP *j* (US$ Million)	785	87,900	14,200	18,400.00	1.57	120
Distance (weighted) Km	421.96	950.22	627.75	197.11	0.82	120
Population *i* (Million)	21.01	42.71	30.03	6.49	0.21	120
Population *j* (Million)	6.01	56.30	24.60	16.90	0.28	120
Contiguity	0	1	0.75	0.44	-1.18	120
Common Lang. Official	0	1	0.75	0.44	-1.18	120
Common Lang. Ethnic	0	1	0.50	0.50	0	120
Colonial Ties	0	1	0.50	0.50	0	120
Colonial Rel. Post 1945	0	0	0	0	0	120
Inflation	-0.29	15.13	6.28	4.00	0.82	120
Real Effective Exc. Rate	57.98	2,263.78	1302.25	505.08	0.66	120
Net FDI (US$ Million)	121.00	1,340.00	580.00	379.00	0.37	120
Transport Infrastructure *i*	-0.57	0.05	-0.31	0.20	0.49	120
Transport Infrastructure *j*	-0.91	3.08	0.18	1.16	0.68	120
ICT Infrastructure *i*	-0.89	1.68	0.05	1.05	0.55	120
ICT Infrastructure *j*	-0.89	2.10	0.07	0.98	0.89	120
Corruption Index	-1.09	-0.72	-0.90	0.11	-0.51	120
Free Trade Area	0	1	0.64	0.48	-0.61	120

Transport Infrastructure and Trade in EAC

Hausman Test Results

Table F12: Hausman Test Results for Gravity Model

	(b) Fixed	(B) Random	(b-B)	S.E
LGDPi	0.65	0.17	0.48	0.21
LGDPj	0.65	0.49	0.17	0.19
LPOPi	1.63	2.07	-0.44	0.89
LPOPj	-3.70	0.30	-4.00	1.13
LRER	2.15	0.19	1.96	0.34
LGDI	0.01	0.05	-0.03	0.00
INF	0.01	-0.01	0.01	-
ICTi	0.48	0.15	0.00	0.06
ICTj	-0.55	-0.25	-0.30	0.05
INFRAi	-0.47	-0.14	-0.33	0.06
INFRAj	-0.10	-0.09	-0.02	0.06
COINDEX	-0.02	-0.00	-0.02	-
FTA	0.25	0.27	-0.02	0.02

Chi2(13)= 36.50

Prob>chi2=0.105