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Key Issues in Regional Integration **Vol XII**

30 Years of COMESA Regional Integration:

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Acronyms and Abbreviations

ADF	Augmented Dickey Fuller
AfDB	African Development Bank
AIDI	African Infrastructure Development Index
AMU	Arab Maghreb Union
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
AU	African Union
CEN-SAD	Community of Sahel–Saharan States
CEPII	Centre d'Etudes Prospectives et d'Informations Internationales
CIA	Central Intelligence Agency
CM	Common Market
COMESA	Common Market for Eastern and Southern Africa
COMSTAT	COMESA statistics
COVID-19	Coronavirus disease 2019
CU	Customs Union
DiD	Difference-in-Difference
DRC	Democratic Republic of the Congo
EAC	East African Community
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
EU	European Union
FDI	Foreign Direct Investment
FE	Fixed Effects
FTA	Free Trade Area
GDP	Gross Domestic Product
HIC	High Income Country
IATA	International Air Transport Association
ICT	Information Communication Technology
IGAD	Intergovernmental Authority on Development

IMF	International Monetary Fund
ITC	International Trade Centre
LIC	Low Income Country
LLC	Levin Lin Chu
MIC	Middle Income Country
NTBs	non-tariff barriers
NTT	New Trade Theory
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Square
OSBP	One Stop Border Post
PMG	Pooled Mean Group
PP	Phillips-Perron
PPML	Poisson Pseudo Maximum Likelihood
PPMLHDFE	Pseudo Poisson Maximum Likelihood with High Dimension Fixed Effects
PTA	Preferential Trade Area
RE	Random Effects
REC	Regional Economic Community
ROW	Rest of the World
RTAs	Regional Trade Agreements
SAARC	South Asian Association for Regional Cooperation
SAATM	Single African Air Transport Market
SADC	Southern African Development Community
SEM	Structural Equation Model
SFA	Stochastic Frontier Analysis
SFGM	Stochastic Frontier Gravity Model
SSA	Sub-Saharan Africa
UNCTADstat	United Nations Centre of Trade and Development Statistics
US$	United States Dollar
VIF	Variance Inflation Factor
WDI	World Development Indicators
WEF	World Economic Forum
WTO	World Trade Organization

PREFACE

Key Issues in Regional Integration is an annual publication of the Secretariat of the Common Market for Eastern and Southern Africa - COMESA. To date 11 editions have been published. This is the 12th edition and focuses on **"30 Years of COMESA Regional Integration: Retrospect and Prospects"**.

The regional economic bloc was initially established in 1981 as the Preferential Trade Area for Eastern and Southern Africa (PTA). In 1994, it was transformed into the Common Market for Eastern and Southern Africa (COMESA) within the framework of the Organization of African Unity's (OAU) Lagos Plan of Action and the Final Act of Lagos.

The COMESA Free Trade Area (FTA) was launched on 31 October 2000 after a 16-year period of progressive trade liberalization through the gradual reduction of intra-COMESA tariffs. As of December 2022, 16 Member States were participating in the FTA, while the remaining five—Ethiopia, Eritrea, Eswatini, the Democratic Republic of Congo, and Somalia—were at different stages of joining the arrangement. The COMESA Rules of Origin are applied to determine whether goods produced within the region qualify for preferential treatment under the FTA.

Since the establishment of the FTA, intra-COMESA exports have grown from US$1.5 billion in 2000 to US$12.8 billion in 2021 (COMSTAT, 2022). Despite this significant growth, intra-COMESA trade still accounts for only about eight percent of the bloc's total exports. Furthermore, the region's untapped intra-export potential is estimated at US$101.1 billion, based on 2019 data. Key constraints limiting the realization of this potential include weak productive capacities, poor infrastructure connectivity, high transport costs, the slow or incomplete implementation of the FTA, non-tariff barriers, and limited product diversification.

To address these challenges, COMESA has developed and implemented several trade and transport facilitation instruments. These include the COMESA Yellow Card Scheme, the Regional Customs Transit Guarantee (RCTG) Scheme, the Non-Tariff Barriers (NTBs) Online Reporting, Monitoring and Elimination Mechanism, One-Stop Border Posts (OSBPs), and the Simplified Trade Regime (STR).

This publication presents a collection of empirical and policy papers developed under the overarching theme, "30 Years of COMESA Regional Integration: Retrospect and Prospects." The papers examine critical sub-themes, including the role of the COMESA Free Trade Area (FTA) in promoting trade efficiency, and the contribution of various transport modes (road, rail, air, and maritime) to intra-COMESA trade.

The purpose of this edition is to deepen readers' understanding of key issues relevant to the regional integration agenda, particularly in the context of COMESA's implemented programmes and the region's experiences with tariff liberalization and trade facilitation. The publication targets a broad audience encompassing academia, researchers in international trade, and government officials.

The production of this edition commenced with a call for extended abstracts in January 2023, which culminated in the presentation of selected research papers at the 10th COMESA Annual Research Forum, held virtually from 11 to 13 September 2023. All papers underwent a rigorous quality assurance process to uphold the integrity and credibility of the findings. The empirical studies primarily relied on secondary data sources.

The distinctive feature of this edition lies in the empirical depth of the analyses and the meaningful engagement of both academia and industry during the research forum and the peer review process.

The successful completion of this publication was made possible through the contributions of numerous institutions and individuals whose support is gratefully acknowledged. Special recognition is extended to the COMESA Secretariat, under the leadership of the Secretary General, Her Excellency Chileshe Mpundu Kapwepwe, and to the Division of Trade and Customs, under the stewardship of Dr. Christopher Onyango. The support of the editorial team (Jane Kibiru, Tasara Muzorori, Caesar Cheelo, Adam Willie and Mwangi Gakunga) is highly appreciated.

The Effects of Transport Infrastructure on Intra-regional Exports in COMESA

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Abstract

The study applied the augmented gravity model to examine the effect of transport infrastructure on exports in COMESA between 2011-2020. The findings indicate that GDP, population, and distance positively affect intra-COMESA exports. However, landlocked countries are likely to trade less and incur more expenses when trading with other countries. In addition, increasing the quality of road and railway infrastructure of the exporter both increase the volume of exports in COMESA region for both Low Income (LICs) and High Income (HICs). However, the small magnitude trade effects of quality transport infrastructure suggest that improvements in road, railway, air, and water transport infrastructure alone may not be sufficient to facilitate trade flows within the COMESA region. The study recommends that; there is a need to strategically improve the quality of road transport infrastructure as a supportive transport mode to the access and use of air transport in low-income countries; Secondly, given that LICs have scarce resources for infrastructure development, priority in resource allocation should be given to improving the quality of road infrastructure; and lastly, there is need to tailor COMESA interventions on transport infrastructure improvement to the level of income of Member States as a one-size fits all approach may not suit both LICs and MICs.

1 Introduction

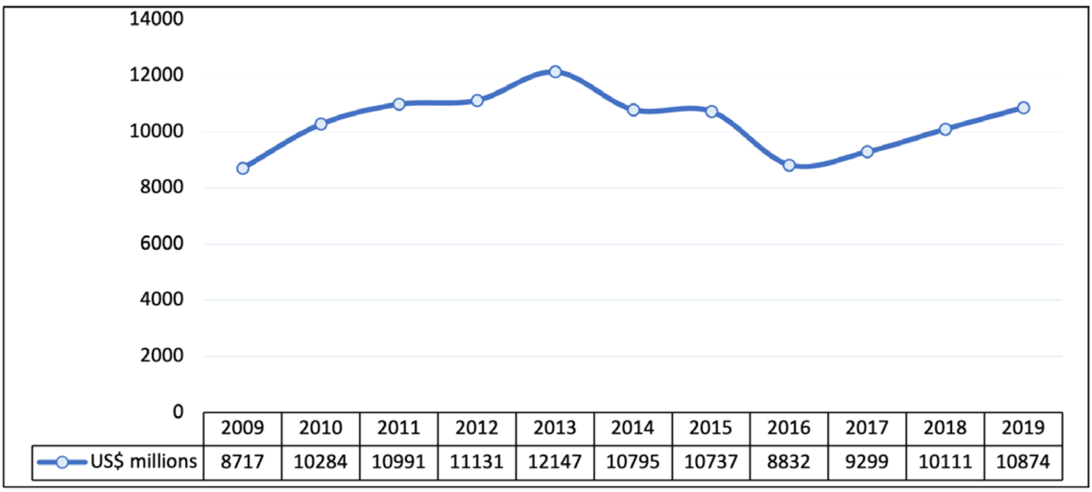
1.1 Background

In trade discourse, infrastructure largely refers to 'physical infrastructure'[5] that is comprised of airports, roads, railways, and ports (transport infrastructure), whose improvement and consequent creation of dependable logistics networks can reduce trade costs, by minimizing transport costs of goods and services (Ragoobur et. al, 2023). The quality of regional infrastructure is critical for effective trade integration, which is a key ingredient for functional Free Trade Areas (FTAs), especially for trade partners that enjoy geographical proximity (Akpan, 2020; Aldrine ***et. al***, 2023).

Transport infrastructure which includes roads, railways, ports, and airports, is essential in facilitating how goods and services move across borders. This is in terms of reducing trade barriers, lowering transportation costs, and improving overall trade performance within a regional economic community (Ahmad et al., 2015). The cost of freight is thrice more in Africa (except North Africa) compared to other regions (UNCTAD, 2020). The logistic performance index also ranks Sub-Saharan Africa (SSA) as the most infrastructurally deficient region regarding transport, hampering intra-regional trade performance (Seid, 2013). In addition, Africa's paved road network is only 25 percent, compared to the world average of over 50 per cent (ECA, 2018). This is due to factors such as poor road maintenance and lack of investment in quality roads among others. Africa's road network also differs across the continent in terms of coverage and quality. Hence poor connectivity and shortfalls in transport infrastructure are a challenge to the growth of intra-regional trade.

The COMESA comprises 21 countries: Burundi, Comoros, Djibouti, Egypt, Kenya, Libya, Madagascar, Malawi, Mauritius, Rwanda, Seychelles, Sudan, Tunisia, Uganda, Zambia, Eritrea, Ethiopia, Eswatini, Somalia, DR Congo and Zimbabwe. Initiatives have been made to liberalize trade and reduce non-tariff barriers within the bloc, however, trade among COMESA Member States remains low. For example, past trends show an increase in intra-COMESA trade between 2009 and 2019 by approximately 24 per cent from US$ 8.7 billion in 2009 to US$ 10.8 billion in 2019 (Figure 1).

Figure 1: Intra-COMESA total exports 2009-2019 (values in US$)



Source: *Authors' computation using data from COMSTAT Data Hub*

5 Hard infrastructure includes transport infrastructure but also ICT, energy, and irrigation among others.

Despite this increase, however, intra-COMESA exports remain minimal in comparison to other regional blocs. According to UNCTAD (2020), intra-COMESA exports constituted 7 percent of total exports in COMESA in 2019, whereas trade amongst countries in the European Union (EU) stood at (62.7 percent). In the Association of Southeast Asian Nations (ASEAN), trade within the region was recorded at 22.6 percent, intra-regional trade in Southern African Development Community (SADC) was at 20.2 percent and East African Community (EAC) at 17.1 percent. In terms of individual country trade composition, Egypt, Kenya, and Zambia dominated trade in COMESA in 2021, valued at US$ 3.7 million, US$ 3.2 million and US$ 2.2 million respectively. Egypt exported most to the bloc with exports worth US$ 2.8 million followed by Kenya US$ 2 million and Zambia 1.5 million in 2021 (Table 1).

Table 1: Intra-COMESA trade, 2021 (US$ million)

	Intra-COMESA Exports	Intra-COMESA Imports	Intra-COMESA Trade
Eritrea	-	10	10
Comoros	3	12	15
Seychelles	14	58	72
Burundi	57	197	254
Eswatini	240	21	261
Madagascar	53	246	299
Djibouti	167	200	367
Mauritius	221	191	412
Malawi	206	239	445
Somalia	3	607	610
Zimbabwe	83	607	690
Ethiopia	521	539	1,060
Rwanda	660	445	1,105
Tunisia	792	386	1,178
Libya	255	1,673	1,928
Uganda	755	1,213	1,968
DR Congo	1,513	511	2,024
Sudan	724	1,341	2,065
Zambia	1,577	640	2,217
Kenya	2,086	1,115	3,201
Egypt	2,838	910	3,748
COMESA (Total)	12,768	11,163	23,931

Source: COMSTAT Data Hub

Regarding infrastructural development, COMESA is cognizant of the importance of infrastructure improvement as a tool for facilitating trade and development. Therefore, to enable Member States to attain sufficient infrastructure and fully integrate in the global market, COMESA implemented various initiatives. These include the development of transport corridors, such as the North-South Corridor and the Tripartite Transport and Transit Facilitation Program, with the goal of improving connectivity between COMESA, the East African Community (EAC), and the Southern African

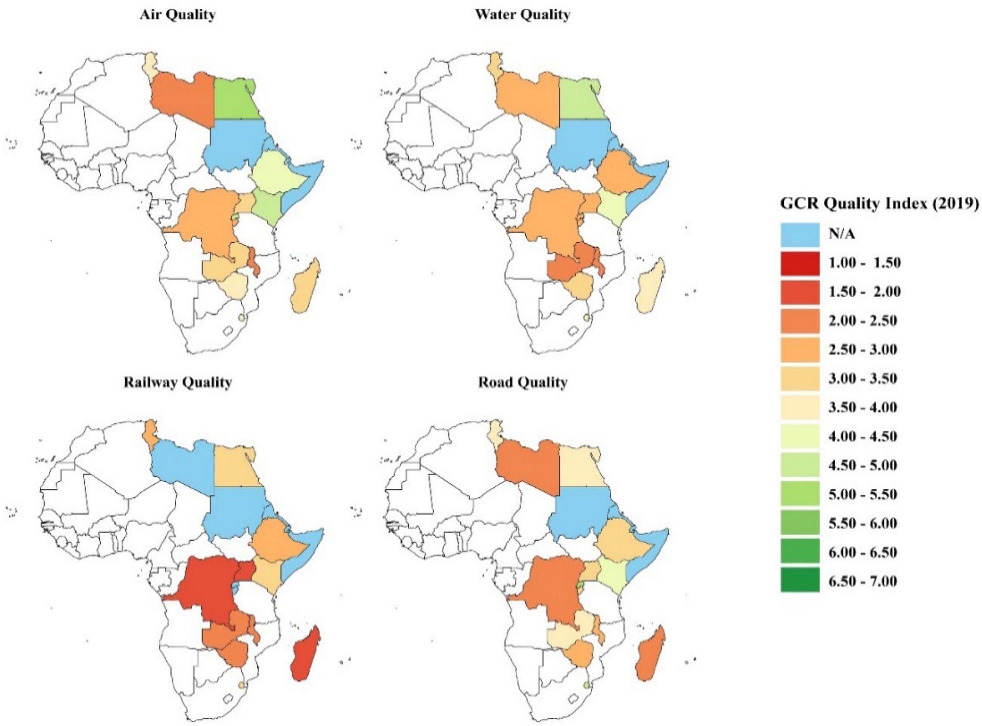
Development Community (SADC).

COMESA's infrastructure programs aim at improving transport, information and communication technology (ICT) and energy (COMESA, 2021). According to Gondwe (2021), transport infrastructure enhances exports and imports if the trading partners have a shorter distance between them. However, inadequate transport infrastructure becomes more expensive as the distance increases. Indeed, the costs of transport in COMESA region are ranked among the most expensive worldwide, with an average of 31.7 percent of the value of imports in seven Member States: including Burundi, Zimbabwe, Malawi, Uganda, Ethiopia Zambia, and Rwanda (ibid). Despite efforts to improve transport, reduce delays and cost of doing business in the region via harmonizing customs and administrative processes at border points, progression to multimodal transport structure is still lacking as the bridge to interlock COMESA Member States.

According to the Global Competitiveness Report (GCR) 2019, factors such as quality, capacity, and connectivity of transport infrastructure, as well as the extent of investment and maintenance in transportation systems provide insights into a country's ability to facilitate the smooth movement of products, expedite customs processes, and enhance accessibility to domestic and international markets, thereby promoting trade and strengthening a country's competitiveness in the global economy. The aforementioned factors are graded in an index on scale from 1 to 7, where 1 means very underdeveloped amongst the worst worldwide and 7 characterizes the common and competent amongst the best in the world (Wessel, 2019).

Figure 2 shows the road, railway, water (seaport), and airport transport infrastructure qualities of the COMESA Member States. It shows that most of the countries in COMESA have a quality index between 2.0 and 4.0, which implies that transport infrastructure is underdeveloped.

Figure 2: Overview of infrastructure qualities in COMESA



Note: ***N/A*** *stands for data Not Available.*

Source: Author's computation using quality of transport indicators from the Global Competitiveness Report, 2019.

1.2 Problem Statement

Despite the efforts made by COMESA to promote trade integration, there remains significant challenges about the condition of transport infrastructure in the region. Inadequate and underdeveloped transport infrastructure can hinder the free movement of goods and services, hence increasing transportation costs, delays, and inefficiencies. These factors pose major obstacles to intra-regional trade and limit the potential economic gains that can be derived from increased trade integration.

Understanding how these factors impact trade flows between Member States requires a study that considers various aspects, such as the quality and connectivity of road networks, the efficiency of railway systems, the capacity and competitiveness of ports and airports, among others. By understanding how transport infrastructure affects intra-regional exports in COMESA, policymakers can develop targeted interventions and investment strategies to overcome the existing challenges and improve the regional trade environment. Policy makers can also gain valuable insights into the specific areas that require improvement to increase trade in the region and advance integration.

1.3 Study Objectives

The general objective of the study is to examine the effects of transport infrastructure on intra-regional exports in COMESA, including road networks, railways, ports, and airports.

Specifically;

a) To examine the effect of transport infrastructure on intra-regional export flows in COMESA.
b) To examine the effects of transport infrastructure quality on COMESA Member States depending on their income levels.

2 Literature Review

2.1 Theoretical Literature

According to the theory of economic integration, economic cooperation between or among economies, without discrimination is necessary to enable countries to exploit their potential within a regional arrangement (Kreinin & Plummer, 2003). According to Balassa (1961), economic integration facilitates sustainable regional arrangements in the long-term (such as Free Trade Area (FTA), Custom Union (CU), Common Market (CM) among others. However, physical connection between or among countries is important to fully integrate within the region. This can be in terms of coordination among neighbouring countries to provide infrastructure (transport, communication, energy etc). Bonilla-Bolaños (2021) argues similarly that investment in public infrastructure benefits economic integration because government largely invests in the improvement of infrastructure to enhance trade via cost reduction. As a result, the benefits of investing in infrastructure by a given country spill over across national borders. Fugimura (2004) explains further that governments design development policies and prioritise where to invest based on the circumstances of the country. However, physical infrastructure especially transport infrastructure is often prioritized because it goes beyond national boundaries.

The natural monopoly theory has also been used to study transport infrastructure centred on the notion of government intervention in the economy via taxation, and regulation. Hotelling (2012) argues that government intervention is critical to reduce market failures in the economy. Infrastructure such as roads and railways should be monopolized and regulated by the government to attain efficiency. The government is also justified to intervene in the market to promote social welfare and allocate resources equitably. Buchanan (1999) further argues that goods, such as transport infrastructure, should be better provided by the public sector, because it is rather difficult to exclude the population from using public goods. McCarthy (2001) also contends that government should intervene where the market fails through regulation to restrict the use of certain technologies, boost competition, and encourage the sharing of information among others.

Estevadeordal et, al (2004) builds on this argument pointing out that infrastructure linkages can be termed as "***club goods***" because several countries within a regional bloc benefit from infrastructural developments such as transport networks which in turn can enhance cross-border trade. However, infrastructure services can be excluded from users in the form of charges or fees. An example is landing fees levied at regional airports to meet costs of regional air traffic control procedures or charges levied at regional seaports. These charges cover the improvement and maintenance of infrastructure owing to congestion, reduction in traffic speed along transport corridors, and decrease in the quality.

Arce and Sandler (2002) add that regions often meet challenges in promoting cooperation due to competition among countries for regional supremacy, despite having the same level of economic development, population, and landforms among others. Governments do not wish other countries to take lead in the provision of and development of public goods in the region. Some countries also may lack the capacity, expertise, to carry out quality infrastructure developments. Hence this lack of cooperation on the share of benefits from joint regional infrastructure initiatives can be a constraint to regional development.

It is noteworthy however, that the theory of economic integration complements the theory of natural monopoly. The theory of economic integration argues for coordination between or among countries to provide services such as infrastructure which is important to fully integrate within the region because countries benefit from infrastructure development through spillovers. The theory of natural monopoly argues for government intervention to permit efficiency in resource allocation and cooperation across borders via fees or charges for the country and the region to benefit mutually from public goods such as transport infrastructure.

2.2 Empirical Literature

Empirically, some studies find a positive linkage between transport infrastructure and trade while others find a negative relationship. Vidya and Hesary (2021), analyzed bilateral trade data of Association of Southeast Asian Nations (ASEAN) states and China, Japan, and India from 1900-2018. By adopting a Poisson Pseudo Maximum Likelihood (PPML). They find that trade density between the ASEAN and China, Japan and India increased during the period of 1990 to 2018. The infrastructure index indicates a significantly positive effect on connectivity, confirming that expansion of investments in infrastructure increases trade intensity.

Similarly, Ochieng et. al, (2020) analyzed the link between bilateral trade and stock of infrastructure of 11 East African countries using the augmented gravity model and the PPML estimator, for exports from 2000 to 2018 among EAC Member States. They conclude that ICT, transport infrastructure and institutional quality have a positive impact on total bilateral trade volumes in East Africa. Hence expanding the transport infrastructure can enhance the pace of regional integration.

In the same regard, Babu et. al, (2022) investigated how transport infrastructure and institution quality affect trade between the East African Community (EAC), Economic Community of West African States (ECOWAS), Southern African Development Community (SADC) and Economic Community of Central African States (ECCAS), between 2000 and 2018. They used the gravity model for trade and the Poisson-Pseudo Maximum likelihood estimator. They found that transport infrastructure enhances trade in EAC. They concluded that improving the regulatory quality in EAC increases export volumes from the EAC to ECCAS and SADC regions correspondingly.

Aldrine et. al, (2023) in their study examine the effect of logistics performance on trade. They employed the gravity model with bilateral trade data based on 10 ASEAN Member States between 2007 to 2018; they found that improvements in the performance of logistics by the private and government sectors positively impact on the value of exports. Hence partnerships between the private sector and government for the improvement of performance in logistics in ASEAN Member States is critical for enhancing intra-regional trade. They concluded that with the formation of regional blocs, tariffs cease to be the dominant driver of high trade costs, but rather the costs of global trade and domestic logistics. Baita (2020) further analysed the impact of infrastructure quality on trade in ECOWAS, and ECOWAS trading partners in the rest of the world between 2012 and 2016, using the gravity model. He found that bilateral trade increases with improvement in infrastructure quality. In addition, bilateral trade increases in value depending on the size of the economy. He concluded that factors such as geography and structural related factors impact reginal trade.

On the other hand, Akpan (2020) examined the impact of trade and transport infrastructure on trade in ECOWAS from 2000-2017, by adopting the Poisson Pseudo Maximum Likelihood to estimate the augmented gravity model of trade. The study found that trade and transport infrastructure had a negative effect on trade though insignificant. The study concluded that trade and transport infrastructure affect trade via increased trade costs among members which necessitates completion of ongoing road, railway, ports building projects in the region and effecting service delivery to increase regional trade.

Likewise, Njuguna (2013), investigated the impact of trade facilitation on export flows in COMESA. Using the gravity model and data from 2007 to 2010. The study found that trade facilitation shows no significant impact on exports initially, however there is a variation in the latter year of investigation. He adds that while developments in air transport would make the distance insignificant, COMESA mainly relies on rail and road transport, therefore distance remains a significant factor. He further asserts that competing membership in multiple Regional Trade Agreements not only complicates integration but also the regional investments in infrastructure.

2.3 Overview of Literature

The theory of economic integration argues for coordination and cooperation between or among countries to provide services such as infrastructure to fully integrate within the region because countries benefit from infrastructure development through spillovers. The theory of natural monopoly on the other hand looks inward to argue for government intervention in the economy for fair access to public goods and correct market failure through regulation to restrict the use of certain technologies, boost competition, and encourage the sharing of information among others. The empirical evidence is in sync with theory, arguing that joint effort to improve the quality of infrastructure in a regional arrangement facilitates infrastructural development. The lesson learnt from the literature is that individual countries should make effort to expand transport infrastructure, reduce costs and increase the flow of trade much as regional organizations and Regional Economic Communities (RECs) make initiatives.

We note that anecdotal evidence exits on the effects of transport infrastructure on exports among COMESA Member States much as some scholars (such as Babu, 2022: Akapan, 2020: Baita, 2020) studied the effects of transport infrastructure on trade in regional blocs (ECOWAS, ASEAN, SADC, EAC) and individual countries. First, we attempt to address the gap in literature by disaggregating transport infrastructure from variables such as ICT contrary to the aggregation of these variables by other authors studied; and second, we adopt the Poisson Pseudo Maximum Likelihood Estimation (PPML) to cater for zero trade flows and heteroscedasticity to avoid biases, and depict the individual characteristics of countries within the COMESA bloc; Third, we factor in the different levels of income for particular countries to cater for heterogeneity within the COMESA bloc and suggest appropriate interventions.

3 Methodology

3.1 Scope of the Study

The study examines the effect of transport infrastructure on intra-COMESA exports for a period of 10 years (2011-2020). It covers 21 COMESA countries (i.e., Burundi, Comoros, D R Congo, Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Libya, Madagascar, Malawi, Mauritius, Rwanda, Seychelles, Somalia, Sudan, Eswatini, Tunisia, Uganda, Zambia, and Zimbabwe).

3.2 Empirical Methodology

3.2.1 The Gravity Model

The study applies the augmented gravity model to analyse the effect of transport infrastructure on intra-COMESA exports. The model is widely used in trade literature to examine the bilateral trade flows between two countries (Tinbergen, 1962; Linneman, 1966; Anderson, 1979). The model posits that trade flows between two countries (i and j) are proportionate to each country's economic mass (Proxied by GDP or Population size), divided by the physical distance between their capital cities. It postulates that trade volume between countries is an increasing function of their gross domestic product and population size, as geographical distance between their capitals is captured as a decreasing function.

The study defines the basic gravity model as:

$$X_{ij} = \beta_0 Y_i^{\beta 1} Y_j^{\beta 2} D_{ij}^{\beta 3} \quad \text{.......... (1)}$$

Where: β_1, β_2 and β_3 are the estimated parameters. The relationship in equation 1 is log-linearized and parameters are estimated in their short form as denoted:

$$\ln X_{ijt} = \beta_o + \beta_1 Z_{ijt} + \beta_2 \delta_{ijt} + \varepsilon_{ijt} \quad \text{.......... (2)}$$

Where ijt represents the exporting country, importing country and time, respectively; X_{ijt} denotes exports; Z_{ijt} denotes the independent variables; δ is a vector of the modes of transport infrastructure (i.e., road, railway, water and air) Quality and ε_{ijt} is the error term.

3.2.2 Poisson Pseudo Maximum Likelihood Estimation (PPML)

The presence of zero trade flows and heteroscedasticity significantly affects the estimation of gravity models, which may yield biased results (Silva & Tenreyro, 2006, 2011). Therefore, the study adopts the PPML approach as the most preferred technique to estimate the gravity model in equation 2.

The study defines an augmented gravity that will be estimated using the PPML is as follows:

$$X_{ijt} = \beta_o + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln POP_{it} + \beta_4 \ln POP_{jt} + \beta_5 \ln DIS_{ij} + \beta_6 CB_{ij} + \beta_7 CL_{ij} + \beta_8 \delta_{it} + \beta_9 \delta_{jt} + \beta_{10} LL_{ij} + \varepsilon_{ijt} \quad \text{.......... (3)}$$

Where, GDP is the real gross domestic product; POP denotes population, DIS is the distance between the capital cities of the two trading partners i and j; CB is the dummy for a common border; CL is also a dummy variable for a country's official language; LL denotes whether the country is landlocked; δ is a vector of the quality of modes of transport infrastructure; and $\boldsymbol{\varepsilon}_{ijt}$ is the error term.

The PPML estimation technique posits that the sum of the estimated values is virtually identical to the sum of the input values which makes it consistent in the incidence of heteroscedasticity and takes care of the null values of the dependent variable. Estimates dependent on Poisson probability are continual even in cases where the data do not follow a Poisson distribution. Therefore, the PPML is advantageous of converging in heteroscedasticity and robustly addressing the problem of highly concentrated zero values in the dependent variable.

From equation 3, the value of export from country ***i*** to country ***j*** is proportional to the origin (exporting) and destination (importing) countries' economic size, the distance between countries, and the transport infrastructure of both countries. Dummy variables for a common border, common language, and common colony are used as a proxy for trade costs. Following Wessel (2019), the study disaggregates the transport infrastructure variable into different transport modes to analyse the infrastructure trade effects of improvement in the quality of each mode.

3.3 Estimation Technique

While estimating, the study identified the best estimation technique to get the best results. The Ordinary Least Squares (OLS) was rejected as earlier discussed regarding the choice of a model and the remaining options were the Random Effects (RE) and Fixed Effects (FE) models although they equally had their limitations.

When fixed effects model estimation is employed and some variables are stationary over time, the intrinsic change eliminates those variables. Hence, the impact of variables which change over time is best estimated by the models. Many of the variables in the model are do not vary and thus the fixed effects model is not rejected. The ideal scenario is to conduct the Hausman test to choose between the random and fixed effects model, but the random effects model if selected has a is likelihood of exhibiting heteroscedasticity. Therefore, PPML was selected due to its strength and capacity to minimize problems related to the OLS, FE, and RE presented earlier on. However, to deal with the terms of multilateral resistance, the study employs PPML-HDFE as the technique for estimation which permits the use of multiple sources of heterogeneity and over-dispersion and allows for time and country effects (Correia et al., 2020; Abowd et al., 1999;).

3.4 Diagnostic Tests

Following Levin et. al., (2002), the study conducted the Levin Lin Chu (LLC) panel unit-root test to examine the stationarity of the study variables. The LLC panel unit-root test specifies a null hypothesis of H0: panels contain unit roots and the alternative Ha: the panels are stationary. The findings in Table A.2 (in the Appendix) show that the results from the LLC test reject the null hypothesis of no unit root for all the variables in the study, at a 5 percent significance level. Furthermore, the study investigates the direction and magnitude of the linear relationship between the pairs of the variables under study. Table A.3 shows the matrix of the pairwise correlation coefficients, which is also used to check for the presence of multi-collinearity among the explanatory variables. The correlation matrix shows that estimation analysis does not exhibit multicollinearity since the correlation coefficients are lower than 0.80 (Studenmund, 2001).

3.5 Data Type and Sources

In this study, annual panel data for 21 COMESA Member States was employed between the period 2011-2020. The variables are; Exports, Population size, Distance between capital cities, GDP, Common language, Transport index, Landlockedness and Contingency as shown in Table 1. Data was obtained from various sources including Trade Map, World Development Indicators, Centre d'Études Prospectives et d'Informations Internationales (CEPII), and the World Global Competitive Report of the World Economic Forum.

Table 1: Variable description and data Sources

Variable	Description	Expected Sign	Source
Exports	Value of exports from the 21 COMESA countries to 21 COMESA	N/A	Trade Map
GDP_i	Exporter's GDP, PPP (current international $)	Positive	WDI
GDP_j	Importer's GDP, PPP (current international $)	Positive	WDI
Distance	Distance between capital cities of trading partners.	Negative	CEPII
Landlocked	Dummy variable = 1 if the exporting country is landlocked, 0 otherwise.	Negative	CEPII
Contingency	Dummy variable = 1 if the trading partners share a common border, 0 otherwise.	Positive	CEPII
Common language	Dummy variable = 1 if the trading partners share the same official language, 0 otherwise.	Positive	CEPII
Population i	Population of the Exporter Country.	Positive	WDI
Population j	Population of the importing country.	Positive	WDI
Road	It's an index of road quality measured from 1 to 7 [1 = extremely underdeveloped—among the worst in the world; 7 = extensive and efficient—among the best in the world].	Positive	*WGCR*
Railway	It's an index of railway quality measured from 1 to 7 [1 = extremely underdeveloped—among the worst in the world; 7 = extensive and efficient—among the best in the world].	Positive	*WGCR*
Air	It's an index of air quality measured from 1 to 7 [1 = extremely underdeveloped—among the worst in the world; 7 = extensive and efficient—among the best in the world].	Positive	*WGCR*
Water/port	It's an index of the quality port measured from 1 to 7 [1 = extremely underdeveloped—among the worst in the world; 7 = extensive and efficient—among the best in the world].	Positive	*WGCR*

Note: WDI – World Development Indicators; CEPII – Centre d'Études Prospectives et d'Informations Internationales; and WGCR – World Global Competitiveness Report.

4 Discussion of Results

This section provides the empirical findings of the gravity model for the 21 COMESA Member States. The study begins by exploring the characteristics of the variables that were analyzed. Table 2 provides summary statistics of the different variables employed in the study under LIC, MIC and all categories. The findings show that road infrastructure quality in the COMESA region has a minimum index of 2 and maximum of 5. Whereas railway, air, and water indices range between 1.3 – 3.7, 2.4 – 5.3, and 2.1 – 5 respectively.

Table 2: Descriptive statistics of variables used in the study.

Variable	Category	Obs.	Mean	Std. Dev.	Min	Max
Exports	LIC	1240	21.253	1.207	19.11	22.789
	MIC	1540	22.441	1.805	18.184	25.226
	All	3180	21.945	1.598	18.184	25.226
Log of GDP_i	LIC	1760	23.469	1.086	21.763	25.278
	MIC	1720	23.691	1.719	20.582	26.745
	All	3940	23.451	1.496	20.582	26.745
Log of GDP_j	LIC	1695	23.435	1.511	20.582	26.745
	MIC	1693	23.429	1.48	20.582	26.745
	All	3958	23.439	1.493	20.582	26.745
Log of Population_i	LIC	1800	16.948	0.702	16.008	18.56
	MIC	1800	15.803	1.615	13.468	18.444
	All	4020	16.086	1.81	11.379	18.56
Log of Population_j	LIC	1719	16.041	1.839	11.379	18.56
	MIC	1719	16.101	1.819	11.379	18.56
	All	4020	16.086	1.81	11.379	18.56
Log of Distance	LIC	1800	7.638	0.645	5.193	8.9
	MIC	1800	7.936	0.644	5.983	9.052
	All	4200	7.82	0.643	5.193	9.052
Landlocked	LIC	1800	0.667	0.472	0	1
	MIC	1800	0.111	0.314	0	1
	All	4200	0.381	0.486	0	1
Contingency	LIC	1800	0.156	0.363	0	1
	MIC	1800	0.094	0.293	0	1
	All	4200	0.119	0.324	0	1

Common language	LIC	1800	0.556	0.497	0	1
	MIC	1800	0.58	0.494	0	1
	All	4200	0.558	0.497	0	1
Common colony	LIC	1800	0.317	0.465	0	1
	MIC	1800	0.268	0.443	0	1
	All	4200	0.303	0.46	0	1
Road_i	LIC	1400	3.404	0.75	2	5
	MIC	1060	3.672	0.696	2.1	4.8
	All	2900	3.606	0.805	2	5
Road_j	LIC	1226	3.608	0.812	2	5
	MIC	1243	3.587	0.82	2	5
	All	2876	3.595	0.813	2	5
Railway_i	LIC	1000	1.972	0.457	1.3	3.4
	MIC	780	2.738	0.431	2.1	3.7
	All	2060	2.394	0.648	1.3	3.7
Railway_j	LIC	877	2.434	0.646	1.3	3.7
	MIC	888	2.397	0.649	1.3	3.7
	All	2057	2.413	0.645	1.3	3.7
Air_i	LIC	1400	3.551	0.773	2.4	5.3
	MIC	1060	4.355	0.757	2.4	5.3
	All	2900	3.917	0.844	2.4	5.3
Air_j	LIC	1226	3.941	0.836	2.4	5.3
	MIC	1243	3.897	0.836	2.4	5.3
	All	2877	3.919	0.837	2.4	5.3
Water_i	LIC	1400	2.987	0.524	2.1	4.1
	MIC	1060	4	0.606	2.6	5
	All	2900	3.505	0.787	2.1	5
Water_j	LIC	1226	3.512	0.793	2.1	5
	MIC	1243	3.457	.791	2.1	5
	All	2877	3.482	0.792	2.1	5

Source*: Author's Own Construction.*

Note: Countries i and j are exporting and importing countries respectively.

As part of its analytical framework, the study considers four categories of transport infrastructure, more succinctly the quality of Road (Model 1), Railway (Model 2), Air (Model 3), and Water (Model

4) transport infrastructure. Overall, the estimation results reveal that majority of the explanatory variables possess the expected signs and follow to the theoretical foundations of the gravity model.

The findings in Table 4 indicate that the exporter's GDP significantly contributes towards fostering intra-COMESA trade at a 1 percent level of significance. For instance, in model one (1), a 1 percent increase in the exporter's GDP increases exports for COMESA Member States by 0.91 percent. Similarly, Models (2), (3), (4) and (5) reveal that the exporter's GDP have significant positive contribution to intra-COMESA trade, thus implying that Member States should strive to grow their GDP. On the other hand, the effect of the importer's GDP on intra-regional trade is positive but not statistically significant.

The exporter's population significantly determines the volume of intra-COMESA exports at a 1 per cent. In model (1) for instance, a 1 percent increase in the exporter's population upturns intra-regional exports by 0.19 per cent at a 1 percent level of significance. When the population of exporter increases, it means the exporting country now has increased labour force, thus resulting in more goods being produced, and leading to more exports. The population of the COMESA Member States is used as a proxy for market potential and economic activity. Similarly, the population of the importing countries has a positive, but not statistically significant, impact on intra-COMESA exports.

The results show that the distance between trading countries significantly affects the trade volumes among COMESA Member States. Increasing the distance by 1 percent yields a 0.15 percent decrease in intra-regional trade. This finding implies that Member States should strive to increase connectivity to improve accessibility and facilitate trade flows. Similarly, the findings show that landlockedness is associated with lower trade volumes at a 1 percent level of significance. This shows that landlocked COMESA Member States incur more expenses and difficulties in trading with other countries because they lack direct access to maritime trade channels.

Sharing a common border between exporter and importer countries yields higher levels of bilateral trade as shown by the results in Model one (at a 5 percent level of significance). However, models (2), (3), (4) and (5) reveal that sharing border has a positive, but not statistically significant effect on trade volumes in the COMESA region. Similarly, having a shared colonial history creates historical and institutional linkages that promote trust and cooperation between Member States, thus fostering intra-COMESA exports.

The findings show that increasing the quality of the exporting country's road infrastructure significantly increases the volume of exports in COMESA. Findings from model (1) show that at a significance level of 5 per cent, increasing the quality of the exporting country's road infrastructure by 1 percent increases exports within COMESA by 0.05 percent. Similarly, the estimation results of model (5) show that increasing the exporter's road infrastructure quality by 1 per cent increases the volume of exports by 0.14 percent (at a 1 percent significance level). This implies that improving the quality of road infrastructure reduces transportation costs and facilitates intra-COMESA trade by enhancing connectivity. However, the small magnitude of the effect may be attributed to the fact that road infrastructure alone may not be sufficient to facilitate trade flows within the COMESA region. Other factors including border controls, customs procedures, and logistical challenges can hinder its effects on facilitating trade flows. The findings are in harmony with the view that on average the effect of improvements in road quality on trade flows are relatively small (Blyde, 2013). On the other hand, the importing country's road infrastructure is positive, but does not significantly affect exports. Overall, the findings are similar to Limao & Venables, (2001); Nordås & Piermartini (2004); Coşar & Demir (2016); Martincus ***et al***. (2017).

Findings from Model (2) reveal that railway infrastructure quality of both importers and exporters has a positive effect on intra-COMESA trade. Similarly, Model (5) reveals that a 1 percent increase in the exporter's railway infrastructure quality increases intra-COMESA exports by 0.078 percent (at a 10 percent significance level). The small magnitude effect of railway quality on intra-COMESA export volumes could be attributed to underinvestment or inefficiencies in railway infrastructure and connectivity or the existence of more convenient alternative transportation modes that provide better trade facilitation within the COMESA region.

Table 4: Estimation results of the gravity model

Dependent Variable: Exports			**Method: PPML - HDFE**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Log of GDP_i	0.917***	0.934***	0.934***	0.923***	1.028***
	(52.17)	(37.23)	(54.25)	(55.56)	(42.32)
Log of GDP_j	0.0153	0.0229	0.0184	0.000478	0.0294
	(-1.13)	(-0.79)	(-1.09)	(-0.03)	(-1.03)
Log of Population_i	0.190***	0.293***	0.201***	0.202***	0.265***
	(-14.05)	(-11.86)	(-16.62)	(-15.43)	(-10.49)
Log of Population_j	0.0187	0.0324	0.0200	0.00341	0.0268
	(1.63)	(1.04)	(1.56)	(0.24)	(0.92)
Log of Distance	-0.154***	-0.102**	-0.144***	-0.143***	0.0785*
	(6.41)	(2.95)	(5.91)	(5.93)	(2.25)
Landlocked	-0.484***	-0.468***	-0.474***	-0.466***	-0.543***
	(-18.82)	(-15.64)	(-20.50)	(-17.48)	(-18.09)
Contingency	0.134**	0.0204	0.0920	0.0967	0.0309
	(2.66)	(0.31)	(1.84)	(1.92)	(-0.52)
Common language	0.0229	0.0225	0.0486	0.0374	0.0218
	(0.82)	(0.56)	(1.75)	(1.38)	(0.57)
Common colony	0.114***	0.163***	0.0943***	0.103***	0.183***
	(-3.94)	(-3.54)	(-3.45)	(-3.66)	(-3.82)
Road_i	0.0560**				0.148***
	(3.29)				(4.43)

Road_j	0.0165				0.0180
	(1.05)				(0.55)
Railway_i		0.0435			0.0781*
		(1.40)			(2.46)
Railway_j		0.0441			0.0171
		(1.20)			(0.47)
Air_i			-0.0185		-0.263
			(-1.29)		(-6.89)
Air_j			0.0144		0.0100
			(0.85)		(0.31)
Water_i				0.00921	-0.0422
				(0.45)	(-1.59)
Water_j				-0.0206	-0.00665
				(-1.04)	(-0.24)
Constant	2.433***	4.269***	2.622***	2.757***	2.582***
	(6.08)	(7.52)	(6.98)	(7.52)	(3.69)
Observations	1565	762	1565	1565	762
Time FE	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Countries i and j are exporting and importing countries respectively; Robust standard errors are in parentheses.

4.3 Analysis Disaggregated by Country Income Classifications

The validation for the sub-sample analysis is to rule out biases if all COMESA Member States are combined together yet trade effects of transport infrastructure quality may differ across countries depending on their income levels. Therefore, the study subdivided the COMESA Member States into two sub-categories based on the World Bank income classifications groups (i.e., Low-Income Countries (LIC) and Middle-Income Countries (MIC).[6] The High-Income Classification (with only Seychelles) was omitted because it possessed very few observations inadequate enough to be used in a panel analysis. The countries under each sub-category are listed in Table A.1 (see Appendix). As a result, the study adopts a disaggregated approach to investigate the separate trade effects of transport infrastructure in each of the LIC and MIC categories. Similarly, under the sub-sample analysis, most of the control variables are consistent with the standard gravity model expectations.

The results in Table 5 and 6 show that increasing the quality of road transport infrastructure increases

6 World Bank Country Income Classifications. Retrieved from the link: https://training.iarc.who.int/wp-content/uploads/2022/11/2023_World-Bank-Country_Classification_until-July-2023.xlsx

trade volumes for Member States in both LIC and MIC categories at a 1 percent level of significance. However, results from the estimation of both Model (1) and (5) reveal that the trade effects of road infrastructure quality improvements are significantly higher in Member States that fall under the MIC category in comparison to those in LIC. More succinctly, findings from model (1) show that a 1 percent increase in the quality of road infrastructure increases export volumes by 0.1 percent in exporting LIC Member States and 0.24 percent in exporting MIC Member States. On the other hand, the results of the importing countries are positive, but statistically insignificant. These findings are consistent with those of Limao & Venables, (2001), Coşar & Demir (2016), Martincus ***et al***. (2017) and Wessel, (2019).

The trade effects of the exporting country's railway infrastructure quality provided contradicting findings for the LIC and MIC categories at a 1 percent level of significance. Results from Model (2) show that, whereas a 1 percent improvement in the exporter's railway infrastructure quality yields a 0.19 percent reduction in trade volumes for COMESA Member States under the LIC category, it increases exports for the MIC Member States by 0.31 percent. This implies that Member States with relatively high-income levels could easily boost their trade flows by improving the quality of railway infrastructure, in comparison to their counterpart Member States. This unusual finding may be due to the fact that middle-income countries have a relatively higher quality and connectivity of their railroad infrastructure. Second, they tend to engage in more manufacturing and industry activities compared to LICs, which increases the need for bulk transportation using railway. On the other hand, the trade effects of improvement in the quality of railway infrastructure in the importing countries are positive, though statistically insignificant. These results are similar to the findings of Nordås & Piermartini (2004) and Xu, (2016).

Similarly, improvement in air transport infrastructure quality (both the importer and exporter) significantly boosts intra-COMESA trade. However, its effect on trade is more pronounced in middle income countries in comparison to their counterparts in the LIC category. In particular, a 1 percent improvement in air transport quality is linked to 0.098 percent (at a 1 percent level of significance) increase in export volumes, in comparison to a 0.043 percent (at a 10 percent level of significance) increase in Member States under the LIC category. However, the small magnitude of the trade effect of air transport quality (for both LIC and MIC) may be attributed to the high costs associated with air transport and limited utilization of this transport mode for trade in the COMESA region. The effects of trade of importing countries air infrastructure quality are positive, but statistically insignificant. These findings support the findings of Ismail & Mahyideen (2015); Bottasso ***et al***. (2018); Wessel, (2019).

The results show that improvement in the exporting country's quality of water infrastructure substantially increases exports for Member States within the MIC category. At a 1 percent level of significance, a 1 percent increase in quality of water infrastructure leads to a 0.1 percent increase in export volumes. The trade effect of improvement in water infrastructure quality is positive, for Member States in the MIC category. This implies that Member States with relatively high income could easily boost their exports by improving the quality of water (seaport) infrastructure, in comparison to their counterparts. These results are consistent with Bottasso ***et al***. (2018); Wessel, (2019).

Table 5: Estimation results for low-income countries (LIC)

Dependent Variable: Exports			**Method: PPML - HDFE**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Log of GDP_i	1.560***	1.395***	1.572***	1.571***	0.910***
	(17.76)	(8.69)	(18.17)	(21.79)	(6.09)
Log of GDP_j	0.00235	0.0114	0.00576	0.0108	0.0278
	(0.15)	(-0.48)	(-0.30)	(-0.61)	(1.15)
Log of Population_i	0.742***	0.634***	0.794***	0.780***	0.669***
	(-7.45)	(-3.67)	(-8.44)	(-9.09)	(-5.96)
Log of Population_j	0.00452	0.00882	0.00144	0.00678	0.00780
	(-0.34)	(0.35)	(0.11)	(0.49)	(-0.28)
Log of Distance	0.00255	0.0215	0.0129	0.0184	0.00872
	(0.10)	(0.62)	(0.54)	(0.81)	(-0.27)
Landlocked	-1.230***	-0.957***	-1.114***	-1.074***	-0.486***
	(-34.25)	(-13.89)	(-28.07)	(-29.83)	(-3.52)
Contingency	0.0257	0.0718	0.0467	0.0531	0.0544
	(0.78)	(1.75)	(1.42)	(1.60)	(1.37)
Common language	0.0395	0.0285	0.0307	0.0175	0.0364
	(-1.45)	(0.88)	(-1.10)	(-0.69)	(1.18)
Common colony	0.137***	-0.0142	0.117***	0.0901***	-0.0337
	(4.50)	(-0.26)	(3.94)	(3.40)	(-0.83)
Road_i	0.109***				0.255***
	(4.75)				(5.37)
Road_j	0.00144				-0.0566
	(0.08)				(-1.65)
Railway_i		-0.198***			-0.0148
		(-7.68)			(-0.50)
Railway_j		0.0219			0.132***
		(0.74)			(3.94)
Air_i			0.0437*		0.109***
			(2.18)		(3.70)
Air_j			0.0102		-0.0227
			(0.59)		(-0.67)
Water_i				0.0317	0.0580
				(1.06)	(1.52)
Water_j				0.0184	-0.0812**
				(1.09)	(-3.07)
Constant	-1.708***	0.816	-1.018	-1.232**	10.90***
	(-3.50)	(0.76)	(-1.95)	(-3.18)	(5.53)

Observations	682	288	682	682	288
Time FE	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Countries i and j are exporting and importing countries respectively; Robust standard errors are in parentheses.

Table 6: Estimation results for middle-income countries (MIC)

Dependent Variable: Exports			**Method: PPML - HDFE**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Log of GDP_i	1.285***	1.490***	1.148***	1.120***	1.761***
	(48.10)	(38.08)	(40.44)	(41.38)	(46.99)
Log of GDP_j	0.00984	0.00370	0.00650	0.0000848	0.0127
	(-0.81)	(0.15)	(-0.35)	(-0.00)	(-0.60)
Log of Population_i	0.439***	0.820***	0.384***	0.354***	0.923***
	(-23.11)	(-21.58)	(-18.66)	(-18.88)	(-22.77)
Log of Population_j	0.0121	0.00713	0.0128	0.00710	0.00223
	(1.23)	(0.30)	(0.90)	(0.46)	(-0.12)
Log of Distance	-0.139***	-0.0141	-0.138***	-0.146***	-0.00926
	(5.30)	(0.42)	(4.46)	(4.89)	(-0.32)
Landlocked	0.155***	0.0154	-0.0663	-0.141**	0.252***
	(3.42)	(0.30)	(-1.43)	(-3.22)	(4.62)
Contingency	0.0795	0.0615	-0.00225	-0.0146	0.0145
	(1.52)	(0.92)	(-0.04)	(-0.24)	(0.28)
Common language	0.0896**	0.00373	0.119**	0.128***	0.00378
	(2.83)	(0.09)	(3.14)	(3.43)	(-0.11)
Common colony	0.204***	0.0661	0.172***	0.181***	0.00624
	(-5.92)	(1.33)	(-4.84)	(-5.17)	(0.16)
Road_i	0.249***				0.429***
	(15.07)				(11.45)
Road_j	0.00952				0.0011
	(0.70)				(0.05)
Railway_i		0.315***			0.0762
		(9.58)			(1.84)
Railway_j		0.0236			-0.0234

		(0.82)			(-0.90)
Air_i			0.0984***		0.109*
			(5.52)		(-2.32)
Air_j			0.00651		0.0161
			(0.34)		(0.70)
Water_i				0.105***	0.187***
				(4.45)	(-5.04)
Water_j				-0.0105	0.0227
				(-0.46)	(1.14)
Constant	-3.240***	-1.019	-0.345	-0.193	-5.012***
	(-6.91)	(-1.51)	(-0.65)	(-0.37)	(-7.53)
Observations	684	344	684	684	344
Time FE	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Countries i and j are exporting and importing countries respectively; Robust standard errors are in parentheses.

5 Conclusion and Policy Implications

5.1 Conclusion

The study examined the effects of transport infrastructure on intra-COMESA exports using the gravity model. It employed a panel dataset for the 21 COMESA Member States for the period between 2011 and 2020. The study adopts the indices of the quality of transport infrastructure by the Global Competitiveness Report (GCR)- World Economic Forum (ranging on a scale between 1- 7). The study also employed the Poisson Pseudo Maximum Likelihood Estimation with high-dimensional fixed effects (PPML-HDFE) estimation technique to analyse the augmented gravity model. Furthermore, the study adopts a sub-sample analysis (depending on the World Bank income classification category – Low Income Countries and Middle-Income Countries) to capture the trade effects of transport infrastructure quality improvements in the COMESA region.

Overall, the empirical findings show that most of the explanatory variables (including GDP, population growth, contingency, common colony, common language, and landlockedness) have the anticipated signs and are in line with theoretical foundations of the gravity model. Focusing on the transport infrastructure, the exporting country's road and railway transport infrastructure has a positive and significant effect on intra-COMESA trade. The improvements in the quality of water and air transport infrastructure have an insignificant effect on trade in the COMESA region. The results from the disaggregated LIC and MIC categories indicate that the trade effects of improvements on the quality of the exporters road, railway, water, and air transport infrastructure are significant and positive, however the magnitude of the effects is more pronounced in the Member States that fall under the MIC category. This is evidence that the trade effects of transport infrastructure quality are affected by the level of income. Possibly, this indicates availability of resources to improve transport infrastructure and associated services in MICs relative to LICs. The differential trade effects of transport infrastructure quality imply that a one-size fits all intervention may not work for both LICs and MICs. The relatively small magnitude trade effects of quality transport infrastructure suggest that improvements in road, railway, air, and water transport infrastructure alone may not be sufficient to facilitate export trade flows within the COMESA region. This may form the agenda of future research.

5.2 Policy Implications

The following implications arise from this scrutiny:

a) Governments within the COMESA region should intentionally enhance the quality of road transport. This initiative will support other modes of transport to facilitate access to and utilization of air transport in low-income countries. The goal is to enhance the timeliness of exports, especially perishable goods, and bolster the security of high-value exports in the COMESA region.

b) Recognizing that the trade impacts of transport infrastructure quality are contingent on the level of development, it is imperative for governments in LICs to prioritize infrastructure development during resource allocation. This can be done in collaboration with the private sector, particularly in enhancing the quality of road infrastructure, to maximize trade benefits.

c) It is crucial for the COMESA Secretariat to customize interventions for the improvement of transport infrastructure based on the income levels of Member States. This is because a uniform approach may not be suitable for all COMESA Member States.

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Appendices

Table A.1: List of country income categories used in the study.

COMESA Member States			
All	**Low-Income Countries (LIC)**	**Middle-Income Countries (MIC)**	**High-Income Countries (HIC)**
Burundi	Burundi	Comoros	Seychelles
Comoros	DR Congo	Djibouti	
DR Congo	Eritrea	Egypt	
Djibouti	Madagascar	Kenya	
Egypt	Ethiopia	Libya	
Eritrea	Malawi	Mauritius	
Ethiopia	Rwanda	Swaziland	
Kenya	Somalia	Tunisia	
Libya	Sudan	Zimbabwe	
Madagascar	Uganda		
Malawi	Zambia		
Mauritius			
Rwanda			
Seychelles			
Somalia			
Sudan			
Swaziland			
Tunisia			
Uganda			
Zambia			
Zimbabwe			

Source: World Bank Country Income Classifications (2022-2023). Retrieved from the link: https://training.iarc.who.int/wp-content/uploads/2022/11/2023_World-Bank-Country_Classification_until-July-2023.xlsx

Table A.2: Panel unit root tests

Variable	LLC
Exports	-7.234***
GDP_i	-16.466***
GDP_j	-6.311***
Population i	-8.561***
Population j	-13.452***
Road	-6.238***
Railway	-8.498***
Air	-9.894***
Water/port	-7.456***

Note, ***p<0.01, **p<0.05, *p<0.1 *Source: Author's Computation.*

Dummy variables are excluded from the Panel Unit root tests.

Table A.3: Correlation matrix of the study variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) Log of GDP_i	1.000																
(2) Log of GDP_j	-0.049	1.000															
(3) Log of Population_i	0.784	-0.037	1.000														
(4) Log of Population_j	-0.039	0.784	-0.051	1.000													
(5) Log of Distance	0.115	0.102	-0.087	-0.086	1.000												
(6) Road_i	-0.228	0.006	-0.472	0.023	0.006	1.000											
(7) Road_j	0.004	-0.202	0.021	-0.474	-0.006	-0.063	1.000										
(8) Railway_i	0.100	-0.003	-0.404	0.016	0.229	0.627	-0.042	1.000									
(9) Railway_j	0.000	0.172	0.016	-0.341	0.204	-0.037	0.644	-0.079	1.000								
(10) Water_i	0.030	-0.016	-0.420	0.012	0.188	0.467	-0.021	0.539	-0.052	1.000							
(11) Water_j	-0.019	0.058	0.007	-0.399	0.178	-0.019	0.458	-0.056	0.529	0.019	1.000						
(12) Air_i	0.292	-0.018	-0.128	0.002	0.109	0.620	-0.037	0.412	-0.030	0.726	-0.011	1.000					
(13) Air_j	-0.020	0.287	0.002	-0.147	0.107	-0.037	0.635	-0.034	0.472	-0.014	0.743	-0.048	1.000				
(14) Landlocked	-0.106	0.001	0.183	-0.009	-0.219	0.078	0.001	-0.205	0.011	-0.555	0.031	-0.426	0.023	1.000			
(15) Contingency	0.171	0.170	0.189	0.189	-0.529	-0.034	-0.031	-0.082	-0.065	-0.109	-0.103	0.006	0.001	-0.001	1.000		
(16) Common lang	-0.186	-0.170	-0.188	-0.180	-0.188	0.246	0.236	0.008	0.015	0.110	0.099	0.146	0.139	0.017	0.061	1.000	
(17) Common colony	-0.092	-0.087	-0.099	-0.103	-0.162	0.126	0.124	-0.029	-0.036	0.079	0.080	-0.039	-0.032	0.059	0.078	0.403	1.000

Transport Infrastructure and Bilateral Trade in COMESA

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Abstract

Transport infrastructure has been well documented as an enabler of regional trade. The paper analysed the effect of transport infrastructure - road, rail, maritime, and air on bilateral trade in the Common Market for Eastern and Southern Africa (COMESA) from 2005 to 2021. The gravity model was used for the analysis using the pseudo poisson maximum likelihood estimators (PPML) with time, importer, and exporter fixed effects. The study found that road, maritime, and air transport improve bilateral trade while rail transport dampens it. A percentage improvement in the importer's road transport increases intra-COMESA exports by 0.0051 percent while the combined effect of road transport infrastructure increases it by 0.0002 percent. A percentage increase in railway length routes existing for train service in an exporting country reduces intra-COMESA trade by 1.6281 percent, 0.5731 percent for importing country, and 0.8661 percent for both countries. Liner shipping connectivity increases intra-COMESA bilateral trade by 0.0441 percent for the exporter, 0.0251 percent for the importer, and 0.0016 percent for both countries. Maritime container port traffic for the exporter increases intra-COMESA trade by 0.4577 percent. Regarding air transport, a percentage increase in exporter's air carriers increases bilateral trade by 0.4366 percent. A percentage increase in the number of landings increases intra-COMESA bilateral trade by 0.0000000000572. The study recommends that Member States improve the number of total paved roads and total road networks in kilometers for increased bilateral trade, promote investment in the number of shipping lines serving a country, collaborate in increasing the number of landings across the region, and improve bilateral rail connectivity for increased bilateral trade in COMESA.

Key Words*: COMESA, bilateral trade, transport infrastructure, gravity model, pseudo poisson maximum likelihood.*

1 Introduction

1.1 Background

Transport infrastructure and trade flow nexus has received researchers' attention in recent years. Over time, logistic performance has been used as an indicator of trade facilitation with the quality of transport infrastructure (road, rail, ports, and airports) used as a proxy for infrastructure by Portugal-Perez & Wilson (2012). Transport infrastructure is classified under physical infrastructure and composed of roads, rail, maritime and air. World Bank and World Economic Forum have used these indices to measure transport infrastructure, showing that any improvement in either of the indices improves trade facilitation, reducing the cost of trade and thus ultimately increasing trade flows. For example, Gil-Pajera et al. (2015) argues that high-speed railways reduce commute time, free capacity for low-speed tracks which absorb freight railway thus an advantage to exporters.

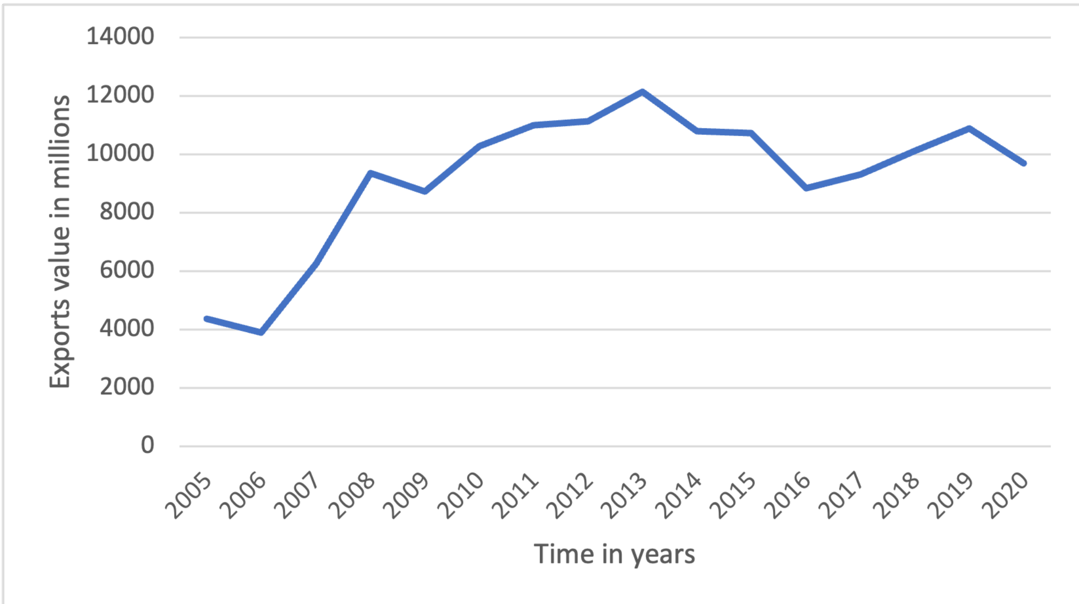
In addition, Baita (2020) shows that bilateral trade in Economic Community of West African States (ECOWAS) increases with the increase in infrastructure quality. However, in the Common Market for Eastern and Southern Africa (COMESA), poor infrastructure continues to derail intra-regional trade (COMESA, 2022). This reinforces outward trade rather than intra-COMESA trade; thus, more investment is required to increase bilateral trade, especially in transport infrastructure as it constitutes the highest trade costs. Costs associated with trade take into account transport costs. Anderson & Wincoop (2004) defines costs associated with trade as costs incurred in delivering goods to the consumer such as transport costs, policy barriers, local distribution costs, information costs, and costs associated with using different currencies. These transport costs are reviewed in this study based on bilateral trade in COMESA.

COMESA Treaty identifies transport infrastructure as an essential area of development. The region's infrastructure pillar revolves around three strategic areas: the development of key priority infrastructure in transport networks (road, rail, water, and air), energy and Information Communication Technology (ICT); policy and regulation; and harmonisation and facilitation. This study focused on the first strategic area - transport infrastructure mainly assessing if road, rail marine and air transport investments reduce trade costs thus stimulating bilateral trade for COMESA Member States.

COMESA is among the Regional Economic Communities (RECs) advancing regional integration at African sub-regional level and act as building blocs for Africa's integration agenda (African Union, 2015). It is the largest common market in Africa, with 21 Member States spread over East, South, Central and Northern Africa. Therefore, interconnectivity through transport infrastructure is important for COMESA's trade integration (COMESA, 2022). Although COMESA countries are connected to each other by roads, trade in COMESA still remains low. Intra-COMESA exports account for about 7 percent of global trade on average. This is low compared to the European Union (EU), which contributes about 34 percent of global trade. Exports within COMESA decreased from US$ 10.11 billion in 2018 to US$ 9.7 billion in 2020 and registered a negative growth of 11.1 percent between 2019 and 2020 (COMESA, 2022). The low levels of intra-COMESA exports are contributed by poor infrastructure connectivity and high transport costs among others making intra-regional trade costly. Overall, this contradicts the gravity model assumptions that trade intensity between two countries is proportional to their economic size and inversely proportional to the distance between them (Anderson & Wincoop, 2004; Tinbergen, 1962).

Figure 1 shows the value of total intra-COMESA exports from 2005 to 2020. Total intra-COMESA trade exports averaged US$ 9,218.17 million with a minimum value of US$ 3,896.42 million and a maximum value of US$ 12,147.50 million. Intra-COMESA total trade exports went up at an increasing rate of 140.21 percent between 2006 and 2008 before declining by 6.86 percent in 2009. The decline in total intra-COMESA trade exports in 2009 can be attributed to the global financial crisis. From 2009 to 2013, the intra-COMESA trade exports increased at a decreasing rate. However, intra-COMESA trade exports decreased between 2013 and 2016 before increasing through to 2019. In 2020, intra-COMESA exports trade declined which could be explained by the effects of COVID-19 global pandemic. Overall, intra-COMESA trade exports fluctuated between 2005 and 2020.

Figure 1: intra-COMESA total exports 2005-2020



***Source**: COMSTAT, 2023*

In general, the Africa Infrastructure Development Index (AIDI) report (2023) ranked five COMESA Member States in the top 10: Seychelles, Egypt, Libya, Mauritius, and Tunisia, with robust investment in transport, power, ICT, water and sanitation. In contrast, five of the 10 least performing countries in the reporting period are also Members of COMESA: Madagascar, Ethiopia, Somalia, Eritrea, and the Democratic Republic of Congo as reported by the African Development Bank (AfDB). These countries have low performance in transport, electricity, water, and sanitation (AfDB, 2023). This could explain the low level of bilateral trade in COMESA as transport is a major tool for facilitating trade, and the main contributing factor to trade costs.

Currently, COMESA has made strides in the four modes of transport infrastructure focused under this study. Under road transport infrastructure, 15 of 21 COMESA Member States have established road funds and road development agencies whose mandate is maintenance and development of road infrastructure for national and regional networks. For rail transport, COMESA has not yet implemented a regional rail line though at bilateral level, countries such as Kenya and Uganda are connected by railway to port Victoria. This slow development in rail lines is perhaps due to the prioritization of passenger investment infrastructure rather than freight transport (Tzanakakis, 2013). Moreover, under marine transport, COMESA is establishing a navigation line to link Lake Victoria and the Mediterranean Sea. Under air transport, although COMESA has not achieved the Single African Air Transport Market (SAATM) target, it has partnered with the EU to support air transport development (COMESA, 2022). Furthermore, three COMESA Member States' national airline serves the region including Ethiopian Airlines, Kenya Airways, and Rwanda Air. Improvements in these modes could boost bilateral trade in COMESA as connectivity is necessary for transporting goods between and across countries.

1.2 Problem Statement

Transport infrastructure is an essential aspect of regional integration in COMESA as shown in COMESA annual reports. Road, rail, maritime, and air are essential hard infrastructures that affect how much a region trades with itself and the rest of the world. High transport costs hinder trade while a well-developed transport infrastructure will positively influence intra-regional trade over time (Egger & Larch, 2007). This is well observed through transport facilitation programmes implemented at bilateral and regional levels like the One-Stop Border Posts (OSBPs), bilateral railways, and Single African Air Transport. COMESA has implemented OSBPs under coordinated border management initiative to ease congestion at border crossing points along transport corridors. Seventeen OSBPs were operational by 2021. Other initiatives like electronic cargo tracking system are under implementation to enable goods transportation and transport from one border to another (COMESA, 2022). These projects, among others, seek to reduce transport costs and ultimately enhance bilateral trade. While strides have been made to improve transport infrastructure in COMESA, intra-COMESA exports remain low accounting for about 7 percent of global trade on average between 2011 and 2015 and 6 percent for the consecutive years to 2019. Between 2019 and 2020 intra-COMESA exports recorded 11.1 percent decline in growth from US$ 10,907.94 million to US$ 9,700.31 million. This could be attributed to poor infrastructure connectivity between countries which then raises the cost of trade. The low intra-COMESA exports negate the gravity model assumptions that trade intensity between country A and B is proportional to the size of their economies and is inversely proportional to their distance (Anderson & Wincoop, 2004; Tinbergen, 1962). Although panel studies focusing on different modes of transport infrastructure have been conducted, these studies are done outside COMESA. Therefore, this paper explores the problem; What is the effect of transport infrastructure on bilateral trade in COMESA? The specific questions to be explored in this paper include;

1. What is the effect of road transport on bilateral trade in COMESA?
2. What is the effect of rail transport on bilateral trade in COMESA?
3. What is the effect of maritime transport on bilateral trade in COMESA?
4. What is the effect of air transport on bilateral trade in COMESA?

1.3 Study Objectives

This study investigates how transport infrastructure affects bilateral trade in COMESA, disaggregating transport infrastructure into four modes: road, rail, maritime, and air transport. The specific objectives are;

1. To analyse the effect of road transport on bilateral trade in COMESA.
2. To analyse the effect of rail transport on bilateral trade in COMESA.

3. To investigate the effect of maritime transport on bilateral trade in COMESA.
4. To assess the effect of air transport on bilateral trade in COMESA.

The findings of this study show the significance of transport infrastructure to bilateral trade flows in COMESA. As such, the findings are important to policy makers in COMESA and at the Member State level as they help in understanding the effects that different modes of transport have on trade. The findings can be used to ascertain if the financial and human capital injected in advancing transport infrastructure by COMESA Member States have had the expected results and which mode of transport requires more attention than the other in regard to its contribution to bilateral trade in the region.

2 Literature Review

2.1 Theoretical Literature

This paper is based on the iceberg cost model. The iceberg model is built upon Samuelson's assumption that trade costs are proportional to the value of goods being traded (Samuelson P. , 1954). The model is used to analyse the effect of trade costs though it was originally used to estimate transport costs. Samuelson argues that inefficient trade procedures will increase trade cost thus creating a gap between the price that producer receive and that which consumer pay for goods. According to the proponents, in order to supply goods ***x*** to country j from country i, then T***ij***(x) goods should be shipped from country ***i***, where the J***ij***(x)>1. As such, to deliver x goods to country ***j***, more than x goods should be shipped from country ***i*** to take care of the constant fraction of goods ***x*** that melts in transit. This implies an inverse relationship between exports and trade costs, which is also expressed by the gravity model of trade (Ferguson & Forslid, 2011). Costs associated with infrastructure are usually incurred by every exporter and importer. As transport costs increase, the total cost of trade also increases thus derailing bilateral trade. This statement can be expressed as;

$$Trade_{ij} = g(Tcosts)$$

Where $Trade_{ij}$ represent bilateral trade between country i and j, and ***Tcosts*** refers to transport costs.

In addition, Krugman developed the new trade theory in 1979 to explain intra-industry trade, also explain trade costs effect on trade. The theory assumes that consumers will prefer varieties, a firms populated market selling a variety of goods and that in production, there is increasing returns to scale. This implies that as the average production cost falls, the volume of production increase. Krugman argues that costs of trade have disproportionate adverse effect on small developing countries. These small countries are characterized by agricultural or natural resource sector that experience constant returns to scale as well as small manufacturing sector contrary to developed countries that are characterized by large manufacturing sector with increasing returns to scale. As such, trade costs result in a reduced trade and disproportionate shift of manufacturing to large, developed nations while the small, developing nations focus on agriculture and natural resource sector.

With open trade and zero trade costs, consumer preference for variety makes consumers in developed countries purchase both foreign and domestic manufactured goods. This results in increased commerce. In contrast, increasing returns to scale gives manufacturing companies in industrialized country advantage costs as market size is big translating to potential large scale of production. Holding other factors constant, consumers in developed economies prefer purchasing lower-cost domestic varieties as opposed to high-cost foreign varieties (World Trade Organization (WTO), 2015). However, this balance is offset by inefficient trade procedures that lead to high costs of trade by making imports of foreign types more expensive than domestic ones. Thus, the demand in developed countries shifts from foreign to domestic manufactured varieties therefore expanding the manufacturing sector in developed countries as it reduces in the small developing countries. Therefore, small economies that want to diversify their economies will want to lower trade costs to reduce the incentive for manufacturing countries to concentrate on developing country's market. As such, small economies invest in programs aimed at reducing trade costs such as those incurred in transportation of goods. Krugman's assumption that trade costs lead to less trade can be represented as;

$$Trade_{ij} = g(TCs)$$

Where $\boldsymbol{Trade_{ij}}$ represent bilateral trade between country i and j, and ***TCs*** refers to transport costs.

These two theories concur that as trade costs rise, the level of trade between countries falls. This study explored trade costs with regard to transport infrastructure and thus, in this case, trade costs are represented by transport infrastructure (road, rail, maritime and air) whose effect is estimated on bilateral trade flows. Literature assumes that as transport infrastructure improves, transport costs decrease thus stimulating trade flows.

2.2 Empirical Literature

Tandrayen-Ragoobur et al. (2022) examined the effect of infrastructural development on bilateral trade for 51 countries in Africa from 2003 to 2015. Three indicators of infrastructural development (soft infrastructure index, hard infrastructure index, and effective infrastructure index composed of soft and hard infrastructure) were used. The hard infrastructure is composed of transport, ICT, and electricity indices. A PPML estimator with high dimension fixed effects (PPMLHDFE) was used to run the model. The results indicate that a 1 percent improvement in the soft infrastructure index would lead to a 0.077 percent increase in trade, and a 1 percent increase in the hard infrastructure index would cause a 0.054 percent improvement in trade. This study did not disaggregate transport infrastructure thus the gap to be filled.

Portugal-Perez & Wilson (2012) investigated the export performance on trade facilitation changes using hard infrastructure index including physical infrastructure: ports, airports, roads, and rail; information and communication technology, and soft infrastructure for 101 developing countries between 2004 and 2007. The findings of a two-stage sample selection model show that a 1 percent improvement in physical infrastructure stimulates trade flows by 0.497 percent. Furthermore, using PPML for robustness, the findings show that a 1 percent improvement in the importer's physical infrastructure translates to a 0.033 percent improvement in trade flows.

Akpan (2014) assessed how regional road infrastructure improvement affect trade across the ECOWAS region. Using the random effects model, the researcher estimated the augmented gravity model with road infrastructure quality as the study's main variable, GDP and distance. The findings show that a 1 percent improvement in the quality of road infrastructure stimulates intra-regional trade in ECOWAS by 0.91 percent. The study contributes to literature by focusing on COMESA and exploring the four modes of transport.

A study by Babu et al. (2022) assessed the role of transport infrastructure and quality institutions on trade between the East African Community (EAC) and three other regional blocs in Sub-Saharan Africa: Southern African Development Community (SADC), Economic Community of Central African States (ECCAS), and ECOWAS between 2000 and 2018. The researchers used augmented gravity model and PPML estimator to run the model. The findings show that transport infrastructure facilitates inter-EAC trade and suggested extra investment in transport-related infrastructure of the East African Community States. This study indicates that a 1 percent improvement in EAC's stock of transport infrastructure leads to a 0.69 percent and a 0.68 percent increase in exports volume to SADC and ECCAS, respectively.

Munim and Schramm (2018) investigated the effect of seaborne trade using quality of port infrastructure and logistics performance. Using a panel of 91 countries for 2010, 2012 and 2014, the authors used the Structural Equation Model (SEM) to show empirical and significant evidence of the two variables. In addition, the researchers conducted a multi-group SEM by dividing the 91 countries into developed and developing countries' groups. The findings show that improvement in port infrastructure leads to improved logistics performance and, ultimately, increased seaborne trade flows.

Rahman et al. (2021) examined the effect of hard and soft infrastructure on a country's trade. The researchers analysed a panel of 21 Asian countries, including China, from 1999 to 2018 using augmented gravity model. Panel ordinary least squares and PPML were applied as estimators. The findings showed that transport proxies, including roads, railways, and maritime transport, positively and significantly affect trade over the period under review. This study focused on road, railway and maritime transport infrastructure leaving air transport thus the gap identified in the study.

Egger and Larch (2007) studied effects on bilateral and multilateral trade of road and railway transport infrastructure using pseudo poisson maximum likelihood estimator between 1999 and 2003. The study adopted cross-sectional data set of more than 32,000 country-pair dyads. Using an augmented gravity model with exporter and importer fixed effects, the findings show a positive impact that varied across countries following the inherent non-linearity of the structural model used. The study focused on the impact of road and railway transport on bilateral trade but was silent on the effect of air and marine transport, which this study seeks to explore in addition to road and rail transport.

On the other hand, Gil-Pajera et al., (2015) using the gravity model estimated how high-speed railway lines influence international trade for 199 countries between 1960 and 2012. A PPML estimator shows that there is a positive but moderate effect of high-speed railway lines on international trade. The authors find that high-speed railway lines free resources from the low-speed traditional lines, thus creating a higher cargo management efficiency and ultimately trade costs reduction. Rather than focusing on railways, the researchers add to this study by also exploring road, air and maritime transport in 18 countries across the COMESA region.

Lai et al. (2019) investigated whether trade and transport logistics activities are mutually reinforcing across Association of Southeast Asian Nations (ASEAN). The authors focused on air and maritime transport infrastructure and estimated the model using simple linear regression against a one-year lagged ASEAN trade variable. Data used covered the period 2000 to 2003 and the fixed-effects model estimate showed that the performance of maritime transport is positively associated with ASEAN's bilateral trade. The same effect is observed with the air cargo transport variable. Different from Lai et al (2019), the study focuses on COMESA countries and in addition to air, and maritime transport, also focuses on road and rail transport infrastructure.

2.3 Overview of Literature

Theoretical arguments point out that trade costs, including those contributed by poor transport infrastructure increase the cost of trading thus negatively affecting bilateral trade. While there is scientific evidence that transport infrastructure influence trade, most of the studies focused outside the COMESA and did not disaggregate transport (Rahman et al., 2021; Ochieng et al., 2020; Tandrayen-Ragoobur et al; 2022; Akpan, 2014). However, Lai et al. (2019), Egger and Larch (2007) and Rahman et al. (2021) disaggregated transport infrastructure into air, maritime, road and railway respectively. Therefore, with the numerous transport infrastructure initiatives adopted in COMESA to improve trade facilitation and ultimately increase bilateral trade, a study examining how different modes of transport infrastructure affects trade is important for the region. Thus, the study complements the existing knowledge by investigating how transport infrastructure influence bilateral trade in COMESA.

3 Methodology

3.1 Scope

The study explored the nexus between transport infrastructure and bilateral trade in among COMESA Member States with a varied composition of countries per specific objective. In all objectives, the time period was from 2005 to 2021. Regarding the composition of countries included in the study, 18 countries were analysed under the road, seven under the rail, 10 under maritime, and 11 under air. The choice for inclusion of COMESA Member States under each objective largely depended on whether that country's data on a particular indicator was reported for the entire time period. For instance, many countries were considered under road sector because they had reported data as provided by the African Infrastructure Development Index produced by the African Development Bank (AfDB). Similarly, under maritime, only countries with maritime transport data were considered. More so, COMESA has many landlocked countries which have no access to the sea. Regarding air and rail, countries with registered carrier departures worldwide and those for which data on the rail was available were chosen, respectively.

3.2 Model Specification

Since the ground-breaking work of Tinbergen in 1962, the gravity model has been used as the workhorse of international trade in empirical literature (Baier & Standaert, 2020; Carrère, 2006; Elmslie, 2018). The model draws from Newton's gravity model and is used to analyse determinants of international trade (Elmslie, 2018). The basis of Newton's law is that the forces of attraction between two bodies are proportional to the product of their masses and inversely proportional to the square distance between their centres, which is directly applied to bilateral trade analysis (Baier & Standaert, 2020). The law is applied to econometrics, to relate bilateral trade flows to GDP, distance, and other factors that affect trade barriers" (Anderson & Van Wincoop, 2003, p.170).

The gravity model has evolved over the years from the "naïve" Newtonian specification to the modified versions, including resistance to trade with the rest of the world (Baier & Standaert, 2020; Anderson & Van Wincoop, 2003), and regional trading agreements (RTA) (Carrère, 2006). The gravity model applied to trade between two countries (importer and exporter) is specified as similar to Tandrayen-Ragoobur et al. (2020), who followed Anderson and Van Wincoop (2003) specifications as below:

$$EXP_{ij,t} = \frac{Y_{j,t}}{P_{j,t}^{-\eta}} \frac{Y_{i,t}}{\pi_{i,t}^{-\eta}} \chi_{ij,t}^{-\eta} \quad (1)$$

Where EXP_{ij} are exports from country (i) to country (j), $Y_{i,t}$ represents the original country's gross domestic product (GDP), $Y_{j,t}$ is the importer's GDP, $X_{ij,t}$ is a vector of variables such as common language, landlocked, distance, common Colonizer, and free trade area (FTA), customs union (CU), common market (CM) etc), among others, that likely affect trade costs between exporting and importing country (see, Frankel, 1997). In addition, the specification of $X_{ij,t}$ enables the introduction of disaggregated transport infrastructure variables—road, rail, maritime, and air into the gravity model (Tandrayen-Ragoobur et al., 2022). The elasticity of trade flows between a pair of countries is denoted by . Anderson and Van Wincoop (2003) demonstrated that $P_{j,t}$ and $\pi_{i,t}$ (i.e. price indices of a good in importing and exporting nations) are equal and depend on trade barriers and income shares between two countries.

In specifying trade cost determinants, the study follows Tandrayen-Ragoobur et al. (2022), that based their barrier to trade function between country and country on Carrère (2006) by using the equation that follows:

$$\chi_{ij,t} = (D_{ij})^{\delta_1} \left[e^{\delta_2 CL_{ij} + \delta_3 CC_{ij} + \delta_4 CB_{ij} + \delta_5 LL_{ij} + \delta_6 TR_{i,t} + \delta_7 TR_{j,t} + \delta_8 FTA_{ij}}\right] \quad (2)$$

Where X_{ij} is the vector of variables that affect bilateral trade between country i and j country , D_{ij} is the distance between the capital cities of country i and j ; CL is equal to 1 if country i and j use the same official language, otherwise zero; CC is equal to 1 if country i and j were colonised by the same Colonizer, otherwise zero; CB is equal to 1 if country i and j are contiguous, otherwise zero; LL is equal to 1 if country i or j is landlocked, otherwise zero; TR_{ij} is transport infrastructure disaggregated into road, rail, maritime, and air in country i and j ; FTA_{ij} is equal to one if country ij belongs to COMESA FTA, otherwise zero. Our gravity model is finally estimated by applying logs to equation 1 as follows:

$$EXP_{ij,t} = \beta_0 + \beta_1 lnY_{i,t} + \beta_2 lnY_{j,t} + \beta_3 lnD_{ij} + \beta_4 CL_{ij} + \beta_5 CC_{ij} + \beta_6 CB_{ij} + \beta_7 LL_{ij} + \beta_8 TR_{i,t} + \beta_9 TR_{j,t} + \beta_{10} FTA_{ij} + \varepsilon_{ij,t} \quad (3)$$

Where $EXP_{ij,t}$ is intra-COMESA trade exports, β_o is a constant; $\beta_1 ... \beta_{10}$ are parameter coefficients, $\varepsilon_{ij,t}$ are error terms assumed to be normally distributed. β_1 , β_2 , β_4 , β_5 , β_6 and β_{10} are expected to be greater than zero, while β_3 and β_7 must be less than zero (Carrère, 2006).

The ordinary least squares (OLS) estimator enjoyed a large share of use in most bilateral trade studies with gravity modeling mainly using log transformation (Baier & Standaert, 2020). However, even with the use of log-linear models, this is challenging when noninteger values are present in the sample

(Manning & Mullahy, 2001). Furthermore, zero values are most common in many bilateral trade data between pairs, that is, periods when pairs do not trade. The use of log-linear transformation in such cases, therefore, increases missingness in the data (Tandrayen-Ragoobur et al., 2022).

In addition, with heteroskedasticity present in data, the interpretation of OLS as elasticities can be misleading given that the expected logarithm value of a random variable is different from the logarithm of its expected value, that is the Jensen inequality (Motta, 2019; Santos Silva & Tenreyro, 2006). The traditional OLS estimator has been criticised in empirical applications (Blackburn, 2007). Alternative approaches to these problems associated with OLS have been suggested (Frankel et al.,1997; Goldberger, 1968; Manning & Mullahy, 2001). Such include dropping pairs with zero trade, using the bilateral trade plus 1 as a dependent variable or using a Tobit estimator. Unfortunately, these alternatives produce inconsistent estimates as discussed by Santos Silva & Tenreyro (2006).

3.3 Estimation Technique

The study employed the PPML estimator in analysing how transport infrastructure influence bilateral trade in COMESA between 2005 and 2021. The estimator was used because it accounts for heteroskedasticity and multiple fixed effects in the model. Correia et al. (2020) suggest using PPML estimator and applying high dimension fixed effects (PPMLHDFE), which they developed and is readily available in many statistical packages. The estimator is argued as the best in producing efficient results compared to other estimates dealing with zero values (Motta, 2019). Stata 17 was used as an analytical package for this study. The authors employed importer, exporter, and time fixed effects in the PPMLHDFE estimator. Therefore, incorporating fixed effects in equation 3 leads to equation 4 below:

$$EXP_{ij,t} = \beta_0 + \beta_1 lnY_{i,t} + \beta_2 lnY_{j,t} + \beta_3 lnD_{ij} + \beta_4 CL_{ij} + \beta_5 CC_{ij} + \beta_6 CB_{ij} + \beta_7 LL_{ij} + \beta_8 TR_{i,t} + \beta_9 TR_{j,t} + \beta_{10} FTA_{ij} + \alpha_i + \alpha_j + \lambda_t + \varepsilon_{ij,t} \quad (4).$$

Where all coefficients and variables remain as explained in equation 1, 2 and 3 except for α_i, α_j and λ_j. α_i is the exporter's fixed effect, α_j is the importer's fixed effect, and λ_t is the time fixed effect.

3.4 Data Type and Sources

To accomplish the objectives of the study, panel data was used. Yearly observations from 2005 to 2021 were collected across 18 COMESA Member States. The panel data combined both cross-section and time series data increasing the efficiency of econometric estimates by providing a large number of data points which increases the degree of freedom, and reduce collinearity among independent variables (Hsiao, 2005).

The study defined bilateral trade in COMESA as the total merchandise exports from the reporter (exporter) to the partner (importer). Gross Domestic Product (GDP) is operationalized as the final market value of all goods and services produced in either the exporting or importing country over a period of one year measured in million United States Dollars. Distance is defined as the length of space between the capital cities of exporting and importing countries measured in kilometers. Common language is operationalized as the use of the same official language between a pair of countries while common Colonizer entails whether the pair were colonized by the same country. In contrast, landlocked means the country has no access to the coast, it depends on other countries to access the coast, and contiguity refers to whether the pair shares a border. Road, rail, maritime and air transport imply the transportation of goods and personnel from one place to another by road, rail, waterways and aircraft, in that order.

Data was collected from various secondary sources. Data on distance, similar official language, contiguity, landlocked, and common colonizer was collected from the Centre d'Études Prospectives et d'Informations Internationales (CEPII) database. Bilateral trade flow between countries is the dependent variable for which data was collected from the IMF Direction of Trade Statistics. Data on pairs' gross domestic product, air transport, maritime transport, and rail transport was obtained from the World Development Indicators (WDI) provided by the World Bank's databank (World Bank, 2023). Lastly, road transport infrastructure was obtained from the African Infrastructure Development Index (AIDI) of the African Development Bank (AIDI, 2023).

Table 1: Definition and measurement of variables

Variable	**Definition**	**Measurement**
Gross domestic product	Final market value of all goods and services produced in either importing or exporting country in a period of one year.	Million United States Dollars.
Distance	Length of space between the capital cities of exporting and importing country.	Kilometers.
Common language	The use of the same official language between a pair of countries.	Dummy. 1 if countries use the similar official language, and 0 otherwise.
Common Colonizer	When the pair was colonized by the same country.	Dummy. 1 if both were colonized by the same colonizer, and 0 otherwise.
Landlocked	The country concerned has no access to the coast.	Dummy. 1 if the country is landlocked, 0 otherwise.
Contiguity	Sharing of land border between the two countries.	Dummy. 1 if the two countries shares a border, and 0 otherwise.
Road transport	The use of road to transport goods and personnel via from one place to another.	AfDB transport infrastructure index.
Rail transport	The use of rail to transport goods and personnel from one place to another.	Kilometers.
Maritime transport	Transportation of goods and personnel from one place to another by waterways.	Liner shipping connectivity (index) and maritime container port traffic transport (TEU 20-foot equivalent units or 20-foot-long cargo container).
Air transport	Transportation of goods and personnel from one place to another by aircraft.	Number of landings made or flight stages flown.
Religion	Belief in and worship of a supernatural being causing a group of people to have similar characteristics of faith towards the supernatural.	Dummy. 1 if the pair belong to the same religion dominant in each of the pair, and 0 otherwise. For instance, 1 if both countries are Islamic states.

Entry cost	Number of days and procedures taken to form a business in a given country.	Dummy. 1 if the sum of the number of days and procedures to form a business exceed median for both countries, or when the relative cost to form a business measured as a percent of GDP is above median in both countries, and 0 otherwise.

***Source**: Authors, 2023*

4 Presentation and Discussion of Results

4.1 Descriptive Statistics

The study was conducted to analyse how transport infrastructure influence bilateral trade in COMESA. The four modes of transport - road, rail, maritime, and air were used in the study under different objectives. The descriptive statistics are presented in Table 2. The volume of bilateral trade averaged US$2.87 million for the period 2005 to 2021 in COMESA. As expected, the minimum value of export volume is zero indicating the absence of trade and its maximum value recorded is US$1,430 million. Between 2005 and 2021, gross domestic product averaged US$ 43,100 million with the minimum and maximum values of US$723 million and US$426,000 million, respectively. In COMESA, distance between major capital cities averages 3,069.568 kilometers. Also, the shortest distance between two capital cities is about 180 kilometers while the longest distance is about 8,053 kilometers. Road transport infrastructure index averaged 16.474 with a minimum and maximum score of 0.554 and 56.511 respectively. Concerning rail transport, COMESA Member States had an average of about 2,350 kilometers of rail coverage with the associated minimum value of 300 kilometers, whereas, the maximum value was 5,195 kilometers.

Maritime was measured using liner shipping connectivity, and container port traffic. On average, liner shipping connectivity index in COMESA was 16.8180 with the worst score of 1.5091 and the best performance of 68.5087 between 2005 and 2021. Over the same period, the number of containers at the port averaged about 1.14 million with the lowest value of about 44,697 and a maximum value of 7.32 million. Lastly, air transport measured using carrier departures worldwide averaged 30,078 with a minimum and maximum values of 367 and 138,192, accordingly. Descriptives for landlocked, common language, common colonizer and contiguity have not been reported because they are dummies.

Table 2: Descriptive statistics

Variable	Observation	Mean	Std.dev.	Minimum	Maximum
Exports	5202	28.7m	112m	0	1,430m
GDP	5202	43,100m	72,900m	723m	426,000m
Distance	5202	3069.568	1752.605	180.006	8053.869
Road transport	5202	16.474	17.2325	0.5544	56.51111
Rail transport	713	2350.527	1818.21	300	5195
Maritime-liner	1440	16.818	14.1404	1.5091	68.5087
Maritime-container	1170	1140607	1914832	44697	7321888
Air transport	1860	30078	33229	367	138192

***Source**: Authors, 2023*

4.2 Estimation Results

4.2.1 Road Transport and Bilateral Trade in COMESA

The road infrastructure index constructed by the African Development Bank was used. The study findings are presented in Table 3, second column for 18 COMESA Member States[9]. In Table 3, bilateral trade is regressed on traditional gravity variables, while controlling for road transport infrastructure for exporter (reporter), and importer (partner), respectively. Also, road transport infrastructure for both countries was combined to determine its overall effect on bilateral trade. The exporter's road transport infrastructure has a positive but insignificant effect on bilateral trade. On the other hand, the importer's road transport infrastructure was found to positively and significantly affect bilateral trade such that a percentage improvement in road transportation increases intra-COMESA exports by 0.0051 percent in a Member State. Also, the combined effect of road transport infrastructure performance is positive and significant such that a percentage improvement in road transport infrastructure in pairs increases bilateral trade by 0.0002 percent.

For the effect of road transport infrastructure on intra-COMESA trade exports, the findings are similar to that of Ochieng et al. (2020), who found that road infrastructure in EAC positively influences bilateral trade exports. Also, Portugal-Perez and Wilson (2012) found that efficient transportation is associated with increased export trade in developing economies. In addition, Rahman et al. (2021) recognised hard infrastructure's role in improving trade flows between China and 21 Asian economies. Furthermore, the finding of this study conforms to the African Regional Integration Index (ARII) report for 2019, which shows COMESA as a 5th performer in infrastructure integration.

9 Burundi, Comoros, Democratic Republic of Congo, Egypt, Eswatini, Ethiopia, Sudan, Tunisia, Kenya, Libya, Madagascar, Malawi, Mauritius, Rwanda, Seychelles, Uganda, Zambia and Zimbabwe.

Table 3: Regression results for the effect of road, and rail transport on bilateral trade in COMESA

Mode of Transport	Road Transport		Rail Transport	
Variable	Exports PPMLHDFE	Exports PPMLHDFE	Exports PPMLHDFE	Exports PPMLHDFE
Model	(1)	(2)	(3)	(4)
Log (GDP) reporter	0.5699***	0.5654***	1.5497***	1.3178***
	(0.0485)	(0.0474)	(0.2295	(0.2007)
Log (GDP) partner	0.3827***	0.3972***	0.8041***	0.9785***
	(0.0345)	(0.0390)	(0.2080)	(0.2066)
Log (distance)	-1.0728***	-1.0763***	-1.2019*	-0.8914
	(0.10262)	(0.1054)	(0.7133)	(0.8426)
Landlocked	-0.1561	-0.1889	-0.7337	0.7324**
	(0.1213)	(0.1216)	(0.5699)	(0.2900)
Common language	0.0991	0.0967	1.4818***	1.7648***
	(0.1268)	(0.1250)	(0.3778)	(0.4557)
Common Colonizer	0.2612***	0.3200***	-1.5631**	-1.8424**
	(0.0924)	(0.0937)	(0.7518)	(0.8981)
Contiguity	1.2377***	1.1980***	1.5647*	1.8481*
	(0.1933)	(0.1961)	(0.8415)	(1.0019)
COMESA FTA	-0.6068***	-0.6037***	0.0292	0.2154
	(0.0864)	(0.0906)	(0.2735)	(0.3302)
Road transport reporter	0.0036			
	(0.0023)			
Road transport partner	0.0051**			
	(0.0025)			
Road transport pair		0.0002***		
		(0.0000)		

Rail transport reporter			-1.6281***	
			(0.3751)	
Rail transport partner			-0.5731**	
			(0.2735)	
Rail transport pair				-0.8661***
				(0.2188)
Constant	2.0633**	1.9399	-15.9447	-21.1505
	(1.4243)	(1.3709)	(13.0471)	(15.5035)
Number of Obs.	5199	5199	630	630
R-Squared Overall	0.6060	0.6077	0.6005	0.5864

***, ** and * indicate significance at 1%, 5% and 10%, respectively. Standard errors in parentheses.

***Source:** Authors, 2023*

Both the exporter and importer's GDP have a positive and significant effect on intra-COMESA exports trade. A percentage increase in the exporter's GDP is associated with a 0.5699 percent and 0.5654 percent increase in trade, as shown in models 1 and 2 respectively. Similarly, a percentage increase in the importers' GDP improves bilateral trade by 0.3827 and 0.3972 percent. However, bilateral trade significantly declines by 1.0728 and 1.0763 percent per kilometre increase in distance between two capital cities of concerned countries. The study findings conform to the gravity model assumptions that bilateral trade exports is proportional to GDP and inversely proportional to distance between two countries.

Similar to the findings of Baier and Standaert (2020), Tandrayen et al. (2022), Carrère (2006), and Santos Silva & Tenreyro (2006), among others, results of this study, in all cases indicate that distance dampens bilateral trade while exporter and importer countries' GDP stimulates bilateral trade in COMESA. Concerning GDP, increased exporters' GDP signals improved productive capacity to meet both domestic and international demand, hence, the tendency to export more. Similarly, an increased importer's GDP translates into improved disposable income, therefore, the inclination to import more goods (Tandrayen et al., 2022).

When any trading partner is landlocked, our results indicate that trade between these countries declines by 0.1561 percent. Even though the impact of common language is positive in COMESA when analysed in conjunction with road transport, it is insignificant. With respect to common colonizer and common border, the findings show that countries with the same colonizer and sharing a border significantly trade with each other. In particular, having a common colonizer increases intra-COMESA trade by 0.2612 percent while sharing border increases intra-COMESA trade by 1.2377 percent. The implementation of COMESA FTA decreases intra-COMESA trade by 0.6068 percent.

This finding conforms to Santos Silva and Tenreyro (2006), and Tandrayen et al. (2022) but contrary to Carrère (2006), who showed that only when the country concerned is an importing country, then the status of landlocked significantly matters. This result proves that being landlocked negatively impacts bilateral trade between countries. This could be due to the limited use of multimodal transportation (UNCTAD, 2003). For instance, a landlocked country usually has limited maritime services, which affects the efficient transportation of goods. This shows that sea access is important in determining trade (Munim & Schramm, 2018).

When considering the common official language used between trading partners, the results contradict the findings by Baier and Standaert (2020), Santos Silva and Tenreyro (2006), and Tandrayen et al. (2022). This implies that common language in COMESA is not a significant determinant of bilateral trade. Regarding colonial ties and border sharing, the findings are in line with that of Baier and Standaert (2020).

In addition, the results show that COMESA FTA reduces bilateral trade significantly. This is similar to Baier and Standaert (2020), who found FTA to reduce bilateral trade even though they found that FTA also positively impacted bilateral trade in the long run based on the lagged effect of this policy. However, our results contradict Santos Silva and Tenreyro (2006), in which regional trade agreements (RTAs) positively and substantially impacted bilateral trade for a panel of 136 countries. Furthermore, Baier and Standaert (2020) found RTA to have mixed effects on bilateral trade. The negative effect of the COMESA FTA can be attributed to the fact that only 16 of the 21 COMESA Member States belong to the FTA. In addition, there still remain obstacles to bilateral trade in COMESA even among Members of the FTA due to non-tariff barriers reported between and among Members of the FTA (COMESA, 2021).

4.2.2 Rail Transport and COMESA Bilateral Trade

Table 3, third column indicates the results for the effect of rail transport captured by rail lines (total route-km) indicating the length of railway route available for train service, irrespective of the number of parallel tracks on bilateral trade in seven COMESA Member States[10]. Regarding rail transport, the study found that both the exporters and importer's rail transport infrastructure inhibit bilateral trade in COMESA (see Table 3, third column and Appendix 2). For instance, a percentage increase in the length of railway route available for train service in an exporting country reduces intra-COMESA trade by 1.6281 percent and 0.5731 percent for importing country. On the other hand, a percent increase in the length of rail lines for both countries decreases intra-COMESA bilateral trade by 0.8661 percent. This finding is contrary to Egger and Larch (2007) who found railway networks raising intra-continental trade except in Europe. With regards to Europe, this study, complements their findings which showed that railway networks reduced bilateral trade. In addition, this study contradicts the findings of Gil-Pareja et al. (2015) that showed rail transport proxied on the high-speed railway line to significantly and positively increase bilateral trade.

The negative and significant effect of rail transport on bilateral trade in COMESA is attributed to a number of factors: 1) disjointed and disconnected railways in COMESA Member States, for instance, despite being neighbours, Ethiopia and Sudan only recently announced a railway project linking the two countries (Sudan Tribune, 2022); 2) rigidity and expensive rail infrastructure led to its abandonment by many COMESA countries in preference for other modes of transport; 3) even though railway transport is competitive and complementary to road transport, road transport is

10 Democratic Republic of Congo, Egypt, Eswatini, Ethiopia, Madagascar, Sudan and Tunisia.

required for the "last mile"; and 4) differences in gauge width present the most critical constraint to interconnect rail networks in COMESA to benefit bilateral trade (AfDB, 2015).

For other control variables, GDP for the exporter and importer significantly and positively increased intra-COMESA bilateral exports by 1.5497 percent and 0.8041 percent respectively. On the contrary, a percentage increase in distance decreases intra-COMESA trade by 1.2019 percent. Common language, and contiguity positively and significantly affect intra-COMESA bilateral trade by 1.4818 percent, and 1.5647 percent respectively. The findings are such that the exporter and importer's GDP, common language, and contiguity have met ***apriori*** expectations of the gravity theory.

4.2.3 Maritime Transport and Bilateral COMESA Trade

Following Lai et al. (2019), the study adopted the liner shipping connectivity index and container port traffic as measures of maritime transport in 10 COMESA countries[11]. The results in column 2 and column 3 of Tables 4 indicate respectively the effect of maritime transport measures on bilateral trade. The study findings show that improvement in liner connectivity increases intra-COMESA bilateral trade by 0.0441 percent for the exporter, 0.0251 percent for the importer, and 0.0016 percent for exporter and importer. Maritime container port traffic for the exporter increased intra-COMESA trade by 0.4577 percent. This study's results are consistent with the findings of Lai et al. (2019) who among other variables used the liner shipping connectivity index and container port traffic to measure maritime transport. In their study, they found a positive and significant association between an ASEAN country's trade with other ASEAN countries and its performance in maritime transport (Lai et al., 2019).

As in other modes of transport, exporters and importers' GDP positively and significantly stimulates bilateral trade while distance derails it. The exporter's GDP increases intra-COMESA bilateral trade by 0.4607 percent whereas the importer's GDP increases it by 0.4073 percent. A percentage increase in distance between the pair reduced intra-COMESA bilateral trade by 2.8261 percent. The results conform to the gravity model assumptions (Tinbergen, 1962).

4.2.4 Air Transport and Bilateral Trade in COMESA

The study analysed air transport's effect on bilateral trade in COMESA for 11 countries[12]. It proxied air transport using carrier departures worldwide in the exporting country. Table 4, fourth column indicates the findings of the study. Concerning air transport, the study found that it significantly and positively increases bilateral trade at 0.01 level when the carrier is registered in the exporting country. That is, a percentage increase in exporter's air carriers raises bilateral trade by 0.4366 percent. On the contrary, importer's air transport was found to have insignificant effect on bilateral trade in COMESA even though it is positive. When the effect of air transport for exporter and importer was combined, its effect was found to be positive and significant such that it increases intra-COMESA bilateral trade by 0.0000000000572 percent. This finding relates to that of Lai et al. (2019) who found a significant positive correlation between an ASEAN country's trade with other ASEAN countries and its aviation development.

The traditional gravity variables (exporter and importer's GDP, and distance) maintained the expected signs and significance when regressed with air transport infrastructure. That is, the exporters and importer's GDP improve bilateral trade while distance worsens it. The exporter's GDP

11 Comoros, Democratic Republic of Congo, Egypt, Kenya, Libya, Madagascar, Mauritius, Seychelles, Sudan and Tunisia.
12 Egypt, Ethiopia, Kenya, Libya, Madagascar, Malawi, Mauritius, Seychelles, Sudan, Tunisia and Zimbabwe.

increases intra-COMESA bilateral trade by 0.5829 percent while the importer's GDP improves intra-COMESA bilateral trade by 0.4964 percent. Large distance reduces intra-COMESA bilateral trade by 2.035 percent. On the other hand, COMESA FTA stimulates intra-COMESA bilateral trade by 0.8595 percent. This corroborates with the findings by Baier and Standaert (2020), Tandrayen et al. (2022), and Santos Silva and Tenreyro (2006).

Table 4: ppmlhdfe results for the effect of maritime, and air transport on bilateral trade in COMESA

Mode of Transport	Maritime Liner Shipping Connectivity Transport		Maritime Container Port Traffic Transport		Air Transport	
Variable	Exports	Exports	Exports	Exports	Exports	Exports
Model	(1)	(2)	(3)	(4)	(5)	(6)
Log (GDP) reporter	0.4607***	0.7501***	0.4151**	0.7766***	0.5829***	0.8046***
	(0.0737)	(0.0677)	(0.1809)	(0.1495)	(0.0734)	(0.0722)
Log (GDP) partner	0.4073***	0.3618***	0.5468***	0.3263***	0.4964***	0.5129***
	(0.0535)	(0.0450)	(0.1057)	(0.1052)	(0.0963)	(0.0776)
Log (distance)	-2.8261***	-2.5533***	-2.2327***	-2.1430***	-2.035***	-2.004***
	(0.2230)	(0.2388)	(0.1777)	(0.2056)	(0.1626)	(0.1585)
Landlocked	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)
Com. Language	-0.5914***	-0.0698	-0.3097*	-0.1509	-0.1639	-0.1019
	(0.1759)	(0.1633)	(0.1794)	(0.1926)	(0.2269)	(0.2264)
Com. Colonizer	-0.1642	-0.1502	-0.003	0.0062	0.0460	-0.0947
	(0.1706)	(0.1604)	(0.1855)	(0.1927)	(0.1467)	(0.1276)
Contiguity	-0.5010**	-0.7066***	-0.2036	-0.1665	0.0285	-0.0500
	(0.2323)	(0.2529)	(0.2177)	(0.2306)	(0.146)	(0.1745)
COMESA FTA	-0.2648	-0.3665	-0.1127	-0.2812	0.8595***	0.7197***
	(0.0929)	(0.2864)	(0.3636)	(0.4083)	(0.1832)	(0.2287)
Liner reporter	0.0441***					
	(0.0062)					

Liner partner	0.0251***					
	(0.0069)					
Liner pair		0.0016***				
		(0.0004)				
Log (Container) reporter			0.4577***			
			(0.1582)			
Log (Container) partner			-0.0298			
			(0.1138)			
Log (Container) pair				0.0124		
				(0.0091)		
Log (Air) reporter					0.4366***	
					(0.0656)	
Log (Air) partner					0.1089	
					(0.1041)	
Log (Air) pair						5.72e-11*
						(3.07e-11)
Constant	17.1625***	9.775***	5.6816	5.0727	0.1554	-0.3466
	(2.7944)	(3.1304)	(3.457)	(5.5099)	(2.0158)	(2.2744)
Number of Obs.	1170	1170	864	864	1650	1650
R-Squared Overall	0.5521	0.5463	0.5468	0.5278	0.5546	0.5302

***, ** and * indicate significance at 1%, 5% and 10%, respectively. Standard errors in parentheses.

***Source**: Authors, 2023*

4.3 Robustness Check

In this study, the Heckman (1979) sample selection estimator was used to check for robustness . The results of the Heckman sample selection model are comprehensively given in Appendices 6 to 10. On the other hand, Table 5 presents results for the selection equation, that is, the probit model of export participation, and the relationship between the outcome and selection equations. In addition to all control variables in the outcome equation, Helpman et al. (2008) recommend including at least one more control variable in the Heckman selection equation. This variable must affect the probability that these countries engage in trade, but not the volume of such trade once it takes place. Similar to Helpman et al. (2008), this study employed religion and market entry costs as additional control variables in the selection equation. Data on religion was obtained from the CIA World Factbook (2023) while that of market entry cost was gotten from the World Bank's Doing Business Dataset. In the case where entry cost was used, it was transformed so that it varies bilaterally, by multiplying the exporter and importer values (see Helpman et al., 2008). The results for the sample selection model are given in the first part of Table 5 while the second part shows the relationship between the outcome and selection equations.

With respect to road transport, the study used the combined effect of road transport on bilateral COMESA trade to check for robustness and religion was selected in the Heckman selection equation. In line with theory, exporter and importer's GDP, distance, and common coloniser maintained the same signs and significance on the likelihood that the pair will engage in trade. For instance, distance has a negative and one percent statistically significant impact on the probability that the exporter and importer engage in trade. When religion is selected, landlocked has a positive statistical impact on the pair's probability to trade. The impact for contiguity on the probability of two countries engaging in trade is not significant while that of COMESA FTA is statistically significant. Regarding the pair's road transport, the study shows that it has a robust positive and significant impact on the pair's probability to engage in trade. As expected, the selected variable religion was found to have a positive and one percent statistically significant impact on the probability that the two countries engage in trade. The last part of Table 5 shows that sample selection is not a serious issue for the results of road transport and bilateral trade in COMESA.

For rail transport, market entry cost was selected in the Heckman sample selection equation. As indicated, gross domestic product, distance and rail transport remained as expected. That is, they have expected signs and one percent statistically significant impact on the probability that two countries will engage in trade. Other variables changed their signs and significance in the sample selection equation. In addition, market entry cost has an unexpected positive sign which is statistically significant. In reality, market entry costs must have a negative impact on the probability that the pair engage in trade. Using the Wald test of independence of equations, the study findings reject the null of independence of equations. Therefore, sample selection is a serious issue when rail transport is used to determine bilateral trade in COMESA. In this case, further research would be required with alternative over-identification variables to try and deal with this problem.

Maritime transport was checked for robustness using religion as an over-identifying control variable. The findings showed that GDP (exporter and importer), distance, contiguity and liner shipping for exporter and importer were robust to the selection model. However, the over-identifying variable, religion, was found to have a negative and significant impact on the probability that the pair would engage in trade. This is contrary to the expected outcome of religion on the pair's probability to trade. Another suitable over-identifying variable therefore needs to further be looked for to overcome this issue. However, our results show that the two equations are independent of each other at one percent levels of significance.

Finally, robustness of the results for air transport was checked using religion. In particular, the study used the pair's air transport for this purpose. The findings indicate that GDP (exporter and importer), distance, COMESA FTA, and air transport are robust; that, they have significant impact on the probability that the pair will engage in trade. On the other hand, common language common colonizer and contiguity were found to have significance in the selection model as opposed to the PPMLHDFE. The over-indentification variable, religion, maintained the expected positive and statistically significant impact on the probability the two countries engage in trade. The Wald test of independence of equations showed that the null hypothesis cannot be rejected. Therefore, sample selection is not an issue in this case.

Table 5: Heckman sample selection model for robustness of the effect transport infrastructure on bilateral trade in COMESA

Variable Model	LnExports Road (1)	LnExports Rail (2)	LnExports Maritime (3)	LnExports Air (4)
Log (GDP) reporter	0.2815*** (0.0156)	0.3871*** (0.0669)	0.2133*** (0.0386)	0.1321*** (0.0292)
Log (GDP) partner	0.2275*** (0.0153)	0.6237*** (0.0704)	0.2269*** (0.0390)	0.1677*** (0.0303)
Log (distance)	-0.6406*** (0.0483)	-0.3186*** (0.1480)	-0.9068*** (0.0966)	-0.7719*** (0.1035)
Landlocked	0.2911*** (0.0448)	-0.3842** (0.1567)	Omitted	0.3489*** (0.0923)
Common language	-0.2065*** (0.0537)	-0.2359 (0.1482)	0.3509*** (0.1241)	-0.1725 (0.1421)
Common Colonizer	0.7005*** (0.0605)	0.4101** (0.1985)	0.4247*** (0.1300)	0.3890*** (0.1017)
Contiguity	-0.0954 (0.1206)	-0.9531*** (0.2947)	-1.1716*** (0.2716)	-0.7785*** (0.1794)
COMESA FTA	-0.0959** (0.0479)	-0.1202 (0.1488)	1.0074*** (0.1128)	0.4523*** (0.1351)
Religion	0.7111*** (0.0533)		-0.7379*** (0.0956)	0.3929*** (0.1334)
Entry Cost (Pair)		2.15e-06** (8.72e-07)		
Road/Rail/Maritime/Air Reporter			0.0242*** (0.0045)	
Road/Rail/Maritime/Air Partner			0.0311*** (0.0046)	

Road transport/	0.0004***	-0.0976***		0.0254***
Log (Railway) Pair	(0.0000)	(0.0107)		(0.0030)
Constant	-6.6813***	-15.8256***	-4.0267**	-2.9903**
	(0.5823)	(2.7717)	(1.6254)	(1.2310)
/athrho	-0.1478	-3.1892***	-0.0392	0.0684
	(0.0926)	(0.4663)	(0.1081)	(0.1123)
/lnsigma	0.9607***	1.1612***	0.8156***	0.7865***
	(0.0126)	(0.0383)	(0.0236)	(0.0188)
rho	-0.1478	-0.9966	-0.0392	0.0683
	(0.0906)	(0.0032)	(0.1079)	(0.1118)
sigma	2.6134	3.1939	2.2605	2.1958
	(0.0328)	(0.1224)	(0.0534)	(0.0414)
lambda	-0.3835	-3.1831	-0.0885	0.1500
	(0.2387)	(0.1263)	(0.2441)	(0.2459)
Number of Obs.	5199	628	1296	1850

1. Road Transport: LR test of independence of equations (rho = 0): chi2(1) = 3.01 prob > chi2 = 0.0829
2. Rail Transport: LR test of independence of equations (rho = 0): chi2(1) = 46.34 Prob > chi2 = 0.0000
3. Maritime Transport (Liner Shipping): LR test of independence of equations (rho = 0): chi2(1) = 0.14 Prob > chi2 = 0.7127
4. Air Transport: LR test of independence of equations (rho = 0): chi2(1) = 0.35 Prob > chi2 = 0.5559

***, ** and * indicate significance at 1%, 5% and 10%, respectively. Standard errors in parentheses.

***Source**: Authors, 2023*

4.1 Case Studies of Best and Worst Performers in Each Mode of Transport

In analysing the effects of transport infrastructure on bilateral trade based on performance, each country's performance was averaged over the period 2005 - 2021 to determine top and bottom performers in all modes of transport.

The results in table 6, for instance, show that road transport infrastructure for top performers has positive and significant effect on bilateral trade for the reporter, and pair. On the contrary, it was found to be negative and significant for the partner, and pair for bottom performers. This finding shows that high quality road transport infrastructure is important for bilateral trade whereas poor road infrastructure between partner countries reduces the volume of bilateral trade. Therefore, investment in road transport infrastructure is critical for bilateral trade. When performance is accounted for, the gravity model in terms of the effect of distance on bilateral trade ceases to hold for top performers while it is maintained with high magnitude for bottom performers. This could be attributed to high quality roads that reduce the time it takes for freight to move between countries, therefore lowering trade costs, in turn increases bilateral trade. On the other hand, poor road infrastructure adds to trade costs as more time is taken for freight to move between countries. In addition, bad road infrastructure adds to the transporter's maintenance costs, hence heightening trade costs and undermining bilateral trade. With good road infrastructure, common language and landlocked do not matter. Contiguity ensures high trade between the pair when there exists good road infrastructure but dampens it with bad road network.

For rail, the results show that the gravity model holds for the masses of two countries for top performers and violated for bottom performers. Overall, the study found rail to dampen bilateral trade. However, for top performers, there is small negative effect of rail on bilateral trade. Conversely, bottom performers showed large negative effect of rail on bilateral trade (see Appendix 11). Therefore, improving rail lines and connectivity between countries could improve bilateral trade. Regarding maritime transport, the study used liner shipping connectivity to determine the role of performance on bilateral trade. The results in appendix 12 show that top performers witness positive effect, which is insignificant while bottom performers had a negative and significant effect on bilateral trade. With respect to air transport, the effect of air transport for top performers (reporter) was found to be positive and significant contrary to the negative effect for bottom performers (reporter) (see Appendix 13). In all modes of transport, top performers' transport infrastructure improved bilateral trade whereas it dampened it for poor performers. Hence, investment to improve the quality of transport infrastructure is important for bilateral trade.

Table 6: Regression results for the effect of road transport on bilateral trade for best and worst performers in COMESA

Dep: Exports	**Road – Best Performers**		**Road – Worst Performers**	
Model	**1**	**2**	**1**	**2**
Log (distance)	3.2005* (1.6970)	3.6427** (1.6597)	-26.612*** (7.8003)	-23.4694*** (6.9829)
Log (GDP) reporter	1.8294*** (0.3324)	1.9726*** (0.3562)	3.0836*** (0.4952)	2.8902*** (0.4566)
Log (GDP) partner	0.6849** (0.3044)	0.6528** (0.3297)	0.6811** (0.2984)	0.5064* (0.2828)
Landlocked	omitted	omitted	2.0091*** (0.5911)	2.3745*** (0.1986)
Common language	-0.1924 (0.8799)	0.2984 (0.9554)	11.0423*** (3.0375)	9.7815*** (2.5564)
Common Colonizer	14.2581*** (1.7306)	13.0963*** (1.3926)	6.1384** (2.7054)	3.4063 (2.5899)

Contiguity	6.1136** (2.7138)	6.0681** (2.8075)	-24.3971*** (8.3882)	-20.8791*** (7.5023)
FTA	omitted	omitted	-6.9079* (3.8773)	-4.312 (3.6029)
Road transport reporter	0.1471*** (0.0496)		-0.5706 (0.4373)	
Road transport partner	0.0308 (0.0193)		-0.8999*** (0.2297)	
Road transport pair		0.0009** (0.0004)		-0.4216*** (0.1207)
Constant	-84.4293*** (16.8515)	-84.199*** (16.5399)	133.9577** (53.7753)	116.4439*** (49.5029)

***, ** and * indicate significance at 1%, 5% and 10%, respectively. Standard errors in parentheses.

Source: *Authors, 2023*

5 Conclusion and Policy Implications

5.1 Conclusion

The overall objective of this study was to analyse the effect of transport infrastructure on bilateral trade in COMESA. In particular, the effects of road, rail, maritime, and air transport on bilateral trade were investigated. This study used the pseudo poisson maximum likelihood estimator with higher dimension fixed effects on the augmented gravity model. In addition, case studies were undertaken to determine whether performance in the modes of transport is crucial for bilateral trade to warrant investment.

The study found that the effect of transport infrastructure depended on whether the effects studied are for the exporting, importing country or both. The study found that a percentage improvement in the importer's road transport increases intra-COMESA exports by 0.0051 percent. The combined effect of road transport infrastructure increases bilateral trade by 0.0002 percent. Regarding the effect of rail transport, the study found that a percentage increase in the length of railway route available for train service in an exporting country reduces intra-COMESA trade by 1.6281 percent, 0.5731 percent for importing country, and 0.8661 percent for both countries. On the other hand, the findings show that improvement in liner connectivity increases intra-COMESA bilateral trade by 0.0441 percent for the exporter, 0.0251 percent for the importer, and 0.0016 percent for both countries. Furthermore, maritime container port traffic for the exporter increased intra-COMESA trade by 0.4577 percent. Concerning air transport, the study found that a percentage increase in exporter's air carriers raises bilateral trade by 0.4366 percent. The study found that a percentage increase in the number of landings increases intra-COMESA bilateral trade by 0.0000000000572 percent.

Performance in each mode of transport was found to be important for bilateral trade in COMESA as indicated by the findings in case studies. The rationale for case studies is based on the AfDB's transport infrastructure report of 2023 that showed five COMESA Member States among the top performers, and five other Member States among bottom performers. The findings from case studies showed that performance in all the modes of transport infrastructure is critical for bilateral trade in COMESA. For instance, best performers' road transport infrastructure had positive and significant effect on bilateral trade while it was negative and significant for bottom performers.

5.2 Policy Implications

The study shows that COMESA countries can benefit from individual, and combined efforts to improve road, maritime, air, and rail transport infrastructures. Policies aimed at expediting the improvement of transport infrastructure by COMESA Member States are encouraged to stimulate bilateral COMESA trade. Specifically:

- COMESA Member States should improve the number of total paved roads and total road networks in kilometers for increased bilateral trade. Specifically, while investment in national and regional road networks should be prioritized in the region, countries such as Sudan, Democratic Republic of Congo, Ethiopia, Madagascar, and Malawi should invest more to improve national and regional road networks for bilateral trade.
- COMESA Member States should promote investment in the number of shipping lines serving a country aimed at increasing their performance in the overall liner shipping connectivity index. Boosting shipping lines serving Comoros, Seychelles, Tunisia, and Madagascar should be promoted.
- Member States with registered carriers should collaborate with other Member States to increase the number of landings across the region. Madagascar, Malawi, Sudan, and Zimbabwe should increase their air operations in many COMESA Member States to improve bilateral COMESA trade through air transport.
- Member States with existing bilateral rail connectivity should improve them while those without, but with similar gauges should connect to increase bilateral trade, taking into account issues surrounding the development of rail lines at country, and regional level.

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Appendices

Appendix 1: GLS and ppmlhdfe regression results for the effect of road transport on bilateral trade in -COMESA

Variable	Log Exports	Exports	Log Exports	Exports
Model	**RE-GLS** **(1)**	**PPMLHDFE** **(2)**	**RE-GLS** **(3)**	**PPMLHDFE** **(4)**
Log (GDP) reporter	0.928*** (0.0818)	0.5699*** (0.0485)	0.9335*** (0.0818)	0.5654*** (0.0474)
Log (GDP) partner	0.7378*** (0.0774	0.38269*** (0.0345)	0.7443*** (0.0771)	0.3972*** (0.0390)
Log (distance)	-2.4143*** (0.2713)	-1.0728*** (0.10262)	-2.3255*** (0.2660)	-1.0763*** (0.1054)
Landlocked	-0.4219 (0.3033)	-0.1561 (0.1213)	-0.5297* (0.2906)	-0.1889 (0.1216)
Common language	0.3291 (0.3242)	0.0991 (0.1268)	0.3091 (0.3242)	0.0967 (0.1250)
Common colonizer	1.5501*** (0.3284)	0.2612*** (0.0924)	1.5473*** (0.3288)	0.3200*** (0.0937)
Contiguity	1.1822** (0.5181)	1.2377*** (0.1933)	1.2027** (0.5184)	1.1980*** (0.1961)
COMESA FTA	-0.7474** (0.3138)	-0.6068*** (0.0864)	-0.6298** (0.3064)	-0.6037*** (0.0906)
Road transport reporter	0.0214*** (0.0076)	0.0036 (0.0023)		
Road transport partner	0.0156** (0.0072)	0.0051** (0.0025)		

Road transport (exporter and importer)			0.0007*** (0003)	0.0002*** (0.0000)
Constant	-7.7579** (3.0434)	2.0633** (1.4243)	-10.4619*** (3.0678)	1.9399 (1.3709)
Number of Obs.	3258	5199	3258	5199
R-Squared Overall	0.469	0.6060	0.4337	0.6077
Rho	0.6292		0.6297	

Appendix 2: GLS and ppmlhdfe regression results for the effect of rail transport on bilateral trade in COMESA

Variable	Log Exports	Exports	Log Exports	Exports
Model	**RE-GLS** **(1)**	**PPMLHDFE** **(2)**	**RE-GLS** **(3)**	**PPMLHDFE** **(4)**
Log (GDP) reporter	0.3651 (0.3700)	1.5497*** (0.2295)	0.7794*** (0.2734)	1.3178*** (0.2007)
Log (GDP) partner	1.0871*** (0.3260)	0.8041*** (0.2080)	0.7588*** (0.2556)	0.9785*** (0.2066)
Log (distance)	-1.7670 (1.2037)	-1.2019* (0.7133)	-1.9249 (1.1839)	-0.8914 (0.8426)
Landlocked	1.1383 (1.3518)	-0.7337 (0.5699)	-0.2367 (1.0409)	0.7324** (0.2900)
Common language	0.2431 (1.1596)	1.4818*** (0.3778)	0.0634 (1.1394)	1.7648*** (0.4557)
Common colonizer	-0.019 (1.3414)	-1.5631** (0.7518)	0.0663 (1.3224)	-1.8424** (0.8981)
Contiguity	-0.4754 (0.9279)	1.5647* (0.8415)	2.1276 (2.0384)	1.8481* (1.0019)

COMESA FTA	1.8856* (1.0684)	0.0292 (0.2735)	1.5213 (1.0320)	0.2154 (0.3302)
Log (Rail transport) reporter	0.5253 (0.7124)	-1.6281*** (0.3751)		
Log (Rail transport part-ner)	-1.0677** (0.5325)	-0.5731** (0.2735)		
Log (Rail transport) Reporter and partner			-0.4596 (0.3790)	-0.8661*** (0.2188)
Constant	-4.4329 (13.3003)	-15.9447 (13.0471)	-1.9573 (13.0602)	-21.1505 (15.5035)
Number of Obs.	442	630	442	630
R-Squared Overall	0.4763	0.6005	0.4628	0.5864

Appendix 3: GLS and ppmlhdfe regression results for the effect of maritime transport (liner shipping) on bilateral trade in COMESA

Variable	**Log Exports**	**Exports**	**Log Exports**	**Exports**
Model	**RE-GLS** **(1)**	**PPMLHDFE** **(2)**	**RE-GLS** **(3)**	**PPMLHDFE** **(4)**
Log (GDP) reporter	1.1075*** (0.1520)	0.4607*** (0.0737)	1.2137*** (0.1377)	0.7501*** (0.0677)
Log (GDP) partner	0.7140*** (0.1512)	0.4073*** (0.0535)	0.7312*** (0.1366)	0.3618*** (0.0450)
Log (distance)	-2.9009*** (0.4161)	-2.8261*** (0.2230)	-2.9083*** (0.4174)	-2.5533*** (0.2388)
Landlocked	(omitted)	(omitted)	(omitted)	(omitted)
Common language	0.3916 (0.5563)	-0.5914*** (0.1759)	0.5000 (0.5538)	-0.0698 (0.1633)

Common colonizer	1.8371*** (0.5282)	-0.1642 (0.1706)	1.8509*** (0.5299)	-0.1502 (0.1604)
Contiguity	-1.2099 (0.9994)	-0.5010** (0.2323)	-1.3886 (0.9934)	-0.7066*** (0.2529)
COMESA FTA	0.4920 (0.6543)	-0.2648 (0.0929)	0.5776 (0.6512)	-0.3665 (0.2864)
Liner shipping reporter	0.0305** (0.0134)	0.0441*** (0.0062)		
Liner shipping partner	0.0106 (0.0134)	0.0251*** (0.0069)		
Maritime Liner shipping (Exporter and importer)			0.0009* (0.0005)	0.0016*** (0.0004)
Constant	-7.9734 (6.4179)	17.1625*** (2.7944)	-10.5064* (3.0678)	9.775*** (3.1304)
Number of Obs.	841	1170	841	1170
R-Squared Overall	0.5748	0.5521	0.5698	0.5463

Appendix 4: GLS and ppmlhdfe regression results for the effect of maritime transport (container port traffic) on bilateral trade in COMESA

Variable	**Log Exports**	**Exports**	**Log Exports**	**Exports**
Model	**RE-GLS** **(1)**	**PPMLHDFE** **(2)**	**RE-GLS** **(3)**	**PPMLHDFE** **(4)**
Log (GDP) reporter	0.7596*** (0.1646)	0.4151** (0.1809)	0.8800*** (0.1530)	0.7766*** (0.1495)
Log (GDP) partner	0.4520*** (0.1607)	0.5468*** (0.1057)	0.3951** (0.1528)	0.3263*** (0.1052)

Log (distance)	-2.6657*** (0.3808)	-2.2327*** (0.1777)	-2.6748*** (0.3891)	-2.1430*** (0.2056)
Landlocked	(omitted)	(omitted)	(omitted)	(omitted)
Common language	0.4453 (0.5095)	-0.3097* (0.1794)	0.4456 (0.5202)	-0.1509 (0.1926)
Common colonizer	1.6891*** (0.4829)	-0.003 (0.1855)	1.6860*** (0.4943)	0.0062 (0.1927)
Contiguity	-0.4754 (0.9279)	-0.2036 (0.2177)	-0.5303 (0.9471)	-0.1665 (0.2306)
COMESA FTA	-0.0406 (0.6365)	-0.1127 (0.3636)	0.0316 (0.6477)	-0.2812 (0.4083)
Log (Container reporter)	0.6282*** (0.1706)	0.4577*** (0.1582)		
Log (Container partner)	0.2969* (0.1641)	-0.0298 (0.1138)		
Log (Maritime Container) Exporter and importer			0.0331*** (0.0099)	0.0124 (0.0091)
Constant	-5.9083 (5.6022)	5.6816 (3.457)	-1.0013 (6.1197)	5.0727 (5.5099)
Number of Obs.	663	864	663	864
R-Squared Overall	0.6299	0.5468	0.6197	0.5278

Appendix 5: GLS and ppmlhdfe regression results for the effect of air transport on bilateral trade in COMESA

Variable	Log Exports	Exports	Log Exports	Exports
Model	RE-GLS (1)	PPMLHDFE (2)	RE-GLS (3)	PPMLHDFE (4)

Log (GDP) reporter	0.9612*** (0.1141)	0.5829*** (0.0734)	1.0248*** (0.1186)	0.8046*** (0.0722)
Log (GDP) partner	0.5911*** (0.1136)	0.4964*** (0.0963)	0.7646*** (0.1173)	0.5129*** (0.0776)
Log (distance)	-2.4061*** (0.343)	-2.0347*** (0.1626)	-2.4573*** (0.4082)	-2.004*** (0.1585)
Landlocked	(omitted)	(omitted)	(omitted)	(omitted)
Common language	0.9353 (0.5687)	-0.1639 (0.2269)	0.8092 (0.6184)	-0.1019 (0.2264)
Common colonizer	1.4092*** (0.4344)	0.0460 (0.1467)	1.4225*** (0.4712)	-0.0947 (0.1276)
Contiguity	0.0770 (0.6728)	0.0285 (0.146)	-0.0587 (0.7321)	-0.0500 (0.1745)
COMESA FTA	0.4199 (0.5077)	0.8595*** (0.1832)	0.2314 (0.5463)	0.7197*** (0.2287)
Log (Air transport) reporter	0.1291 (0.0953)	0.4366*** (0.0656)		
Log (Air transport) partner	0.3746*** (0.0918)	0.1089 (0.1041)		
Log (Air transport) Exporter and importer			6.47e-12 (3.52e-11)	5.72e-11* (3.07e-11)
Constant	-10.0432** (3.9927)	0.1554 (2.0158)	-10.2048 (44205)	-0.3466 (2.2744)
Number of Obs.	1267	1650	1267	1650
R-Squared Overall	0.5421	0.5546	0.5116	0.5302

Appendix 6: Heckman sample selection model results for the effect of road transport on bilateral trade in COMESA

Heckman selection model				Number of obs	=		5,199
(regression model with sample selection)				Selected	=		3,762
				Nonselected	=		1,437
				Wald chi2(10)	=		1,378.68
Log likelihood =-11420.12				Prob>chi2	=		0.0000

	LnEXP	Coefficient	std.err.	z	p>|z|	[95% conf. interval]	
LnExp							
	LnGDPRep	0.8661	0.0416	20.83	0.000	0.7846	0.9476
	LnGDPPat	0.5406	0.0356	15.17	0.000	0.4707	0.6104
	LnDist	-2.0055	0.1095	-18.31	0.000	-2.2202	-1.7908
	Landlocked	-0.6667	0.1040	-6.41	0.000	-0.8706	-0.4629
	CommonLanguage	0.3362	0.1100	3.06	0.002	0.1206	0.5517
	CommonColonizer	1.3243	0.1123	11.79	0.000	1.1041	1.5445
	Contiguity	1.2586	0.1650	7.63	0.000	0.9352	1.5819
	FTA	-0.6073	0.1052	-5.77	0.000	-0.8135	0.4010
	RoadTrnsprtReport-er	0.0149	0.0029	5.1	0.000	0.0092	0.0207
	RoadTrnsprtPartner	0.0192	0.0027	7.13	0.000	0.1394	0.0245
	Constant	-4.2315	1.3611	-3.11	0.002	-6.8993	-1.5636
select							
	LnGDPRep	0.2815	0.0156	18.01	0.000	0.2508	0.3121
	LnGDPPat	0.2275	0.0153	14.89	0.000	0.1975	0.2574
	LnDist	-0.6406	0.0483	-13.25	0.000	-0.7353	-0.5459
	Landlocked	0.2911	0.0448	6.5	0.000	0.2034	0.3789
	CommonLanguage	-0.2065	0.0537	-3.84	0.000	-0.3118	-0.1012
	CommonColonizer	0.7005	0.0605	11.58	0.000	0.5819	0.819
	Contiguity	-0.0954	0.1206	-0.79	0.429	-0.3319	0.141
	FTA	-0.0959	0.0479	-2	0.045	-0.1898	-0.0019
	Road	0.000356	0.00005	6.66	0.000	0.000251	0.000461
	Religion	0.71115	0.0533	13.34	0.000	0.6067	0.8156
	Constant	-6.6813	0.5823	-11.47	0.000	-7.8226	-5.54
	/athrho	-0.1478	0.0926	-1.6	0.110	-0.3293	0.0336

	/lnsigma	0.9607	0.0126	76.48	0.000	0.936	0.9853
	rho	-0.1467	0.0906			-0.3179	0.0336
	sigma	2.6134	0.0328			2.5499	2.6786
	lambda	-0.3835	0.2389			-0.8513	0.0843
	LR test of indep. Eqns. (rho = 0): chi2(1) = 3.01 Prob>chi2 = 0.0829						

Appendix 7: Heckman sample selection model results for the effect of rail transport on bilateral trade in COMESA

Heckman selection model	Number of obs =	628
(regression model with sample selection)	Selected =	447
	Nonselected =	181
	Wald chi2(9) =	213.79
Log likelihood =-1316.95	Prob>chi2 =	0.0000

	LnEXP	**Coefficient**	**std.err.**	**z**	**p>|z|**	**[95% conf. interval]**	
LnExp							
	LnGDPRep	0.6391	0.1608	3.98	0.000	0.3240	0.9542
	LnGDPPat	0.0530	0.1710	0.31	0.757	-0.2822	0.3881
	LnDist	-1.5818	0.4387	-3.61	0.000	-2.4417	-0.7219
	Landlocked	1.0662	0.4110	2.59	0.009	0.2607	1.8717
	CommonLanguage	0.1839	0.4419	0.42	0.677	-0.6822	1.0500
	CommonColonizer	0.2996	0.5228	0.57	0.567	-0.7251	1.3243
	Contiguity	1.0734	0.7668	1.40	0.162	-0.4295	2.5763
	FTA	0.1364	0.4091	0.33	0.739	-0.6654	0.9383
	LnRail	0.0872	0.0292	2.99	0.003	0.0300	0.1445
	Constant	6.3430	7.1250	0.89	0.373	-7.6219	20.3078
select							
	LnGDPRep	0.3871	0.0669	5.79	0.000	0.2559	0.5182
	LnGDPPat	0.6237	0.0701	8.86	0.000	0.4857	0.7617
	LnDist	-0.3186	0.1480	-2.15	0.031	-0.6086	-0.0286
	Landlocked	-0.3842	0.1567	-2.45	0.014	-0.6913	-0.0770
	CommonLanguage	-0.2359	0.1482	-1.59	0.111	-0.5264	0.0546
	CommonColonizer	0.4101	0.1984	2.07	0.039	0.021	0.7992

	Contiguity	-0.9531	0.2947	-3.23	0.001	-1.5308	-0.3754
	FTA	-0.1202	0.1488	-0.81	0.419	-0.4119	0.1714
	LnRail	-0.0976	0.0107	-9.12	0.000	-0.1186	-0.0767
	Cost	2.15e-06	8.72e-07	2.47	0.014	4.41e-07	3.86e-06
	Constant	-15.8256	2.7717	-5.71	0.000	-21.258	-10.3933
	/athrho	-3.1892	0.4663	-6.84	0.000	-4.1031	-2.2752
	/lnsigma	1.1612	0.0383	30.29	0.000	1.0861	1.2364
	rho	-0.9966	0.0032			-0.9995	-0.9791
	sigma	3.1939	0.1224			2.9628	3.4431
	lambda	-3.1831	0.1263			-3.4306	-2.9356
	LR test of indep. Eqns. (rho = 0): chi2(1) = 46.34 Prob>chi2 = 0.0000						

Appendix 8: Heckman sample selection model results for the effect of maritime transport (liner shipping) on bilateral trade in COMESA

Heckman selection model				Number of obs	=		1,296
(regression model with sample selection)				Selected	=		900
				Nonselected	=		396
				Wald chi2(9)	=		799.72
Log likelihood =-2597.371				Prob>chi2	=		0.0000

	LnEXP	Coefficient	std.err.	z	p>|z|	[95% conf. interval]	
LnExp							
	LnGDPRep	0.9214	0.0671	13.74	0.000	0.7900	1.0529
	LnGDPPat	0.3895	0.0666	5.85	0.000	0.2589	0.5200
	LnDist	-2.9756	0.1861	-15.99	0.000	-3.3403	-2.611
	Landlocked	0	omitted				
	CommonLanguage	0.2072	0.2141	0.97	0.333	-0.2124	0.6269
	CommonColonizer	1.2679	0.1923	6.59	0.000	0.8909	1.6448
	Contiguity	-0.8187	0.3860	-2.12	0.034	-1.5751	-0.0622
	FTA	0.3823	0.2549	1.50	0.134	-0.1173	0.8819
	LinerReporter	0.0444	0.0068	6.51	0.000	0.0310	0.0578
	LinerPartner	0.0333	0.0067	4.99	0.000	0.0202	0.0463
	Constant	4.5330	2.5826	1.76	0.079	-0.5289	9.5949
select							

LnGDPRep	0.2133	0.0386	5.52	0.000	0.1376	0.2890
LnGDPPat	0.2269	0.0380	5.82	0.000	0.1506	0.3033
LnDist	-0.9068	0.0966	-9.38	0.000	-1.0962	-0.7174
Landlocked	0	omitted				
CommonLanguage	0.3509	0.1241	2.83	0.005	0.1077	0.5942
CommonColonizer	0.4247	0.1300	3.27	0.001	0.1699	0.6796
Contiguity	-1.1716	0.2716	-4.31	0.000	-1.7040	-0.6392
FTA	1.0074	0.1128	8.93	0.000	0.7863	1.2285
LinerReporter	0.0242	0.0045	5.42	0.000	0.0154	0.0330
LinerPartner	0.0311	0.0046	6.81	0.000	0.0221	0.0400
Religion	-0.7379	0.0956	-7.72	0.000	-0.9253	-0.5505
Constant	-4.0267	1.6255	-2.48	0.013	-7.2126	-0.8408
/athrho	-0.0392	0.1081	-0.36	0.717	-0.2510	0.1727
/Insigma	0.8156	0.0236	34.52	0.000	0.7692	0.8619
rho	-0.0392	0.1079			-0.2459	0.1710
sigma	2.2605	0.0534			2.1582	2.3677
lambda	-0.0885	0.2441			-0.5670	0.3900
LR test of indep. Eqns. (rho = 0): chi2(1) = 0.14 Prob>chi2 = 0.7127						

Appendix 9: Heckman sample selection model results for the effect of maritime transport (container port traffic) on bilateral trade in COMESA

Heckman selection model	Number of obs = 1,055
(regression model with sample selection)	Selected = 764
	Nonselected = 291
	Wald chi2(8) = 556.89
Log likelihood =-2187.361	Prob>chi2 = 0.0000

	LnEXP	Coefficient	std.err.	z	p>|z|	[95% conf. interval]	
LnExp							
	LnGDPRep	1.1575	0.0659	17.57	0.000	1.0284	1.2866
	LnGDPPat	0.3032	0.1100	2.75	0.006	0.0875	0.5188
	LnDist	-2.4658	0.2214	-11.14	0.000	-2.8998	-2.0318
	Landlocked	0	omitted				

	CommonLanguage	0.4783	0.2378	2.00	0.046	0.0093	0.9413
	CommonColonizer	1.3730	0.2099	6.54	0.000	0.9616	1.7843
	Contiguity	-0.8312	0.4399	-1.89	0.059	-1.6934	0.0310
	FTA	0.2851	0.3189	0.89	0.371	-0.3399	0.9100
	LnContPart	0.3071	0.1385	2.22	0.027	0.0357	0.5785
	Constant	-5.5322	2.6927	-2.05	0.040	-10.8098	-0.2545
select							
	LnGDPRep	0.3239	0.0415	7.81	0.000	0.2427	0.4052
	LnGDPPat	0.1304	0.0609	2.14	0.032	0.011	0.2497
	LnDist	-0.8681	0.1136	-7.64	0.000	-1.0907	-0.6455
	Landlocked	0	omitted				
	CommonLanguage	0.4376	0.1512	2.89	0.004	0.1413	0.7339
	CommonColonizer	0.5162	0.1461	3.53	0.000	0.2298	0.8026
	Contiguity	-1.1272	0.3388	-3.33	0.001	-1.7912	-0.4632
	FTA	1.1238	0.1281	8.77	0.000	0.8726	1.3749
	LnContPart	0.4573	0.0728	6.28	0.000	0.3145	0.6000
	Religion	-0.5935	0.1068	-5.55	0.000	-0.8029	-0.3841
	Constant	-9.7439	1.9200	-5.07	0.000	-13.5071	-5.9808
	/athrho	-0.1783	0.1794	-0.99	0.320	-0.5299	0.1733
	/Insigma	0.8539	0.0276	30.97	0.000	0.7998	0.9079
	rho	-0.1765	0.1738			-0.4853	0.1716
	sigma	2.3487	0.0648			2.2252	2.4792
	lambda	-0.4144	0.4126			-1.2232	0.3943
	LR test of indep. Eqns. (rho = 0): chi2(1) = 1.19 Prob>chi2 = 0.2744						

Appendix 10: Heckman sample selection model results for the effect of air transport on bilateral trade in COMESA

Heckman selection model	Number of obs	=	1,850
(regression model with sample selection)	Selected	=	1,443
	Nonselected =		407
	Wald chi2(10) =		1256.14
Log likelihood = 4003.352	Prob>chi2 =		0.0000

	LnEXP	Coeffi-cient	std.err.	z	p>|z|	[95% conf. interval]	
LnExp							
	LnGDPRep	0.7172	0.0496	14.46	0.000	0.6200	0.8144
	LnGDPPat	0.3743	0.0487	7.69	0.000	0.2789	0.4697
	LnDist	-2.0253	0.1490	-13.59	0.000	-2.3174	-1.7331
	Landlocked	-0.4465	0.1578	-2.83	0.005	-0.7559	-0.1372
	CommonLanguage	1.1134	0.1908	5.83	0.000	0.7394	1.4874
	CommonColonizer	1.3227	0.1469	9.00	0.000	1.0348	1.6106
	Contiguity	0.3628	0.2442	1.49	0.137	-0.1159	0.8415
	FTA	0.6234	0.1977	3.15	0.002	0.0362	0.0564
	LnAir	0.0563	0.0052	8.96	0.000	0.0362	0.0564
	Constant	-1.3608	1.7020	-0.80	0.424	-4.6967	1.9752
select							
	LnGDPRep	0.1321	0.0292	4.52	0.000	0.0748	0.1893
	LnGDPPat	0.1677	0.0303	5.53	0.000	0.1083	0.2270
	LnDist	-0.7719	0.1035	-7.46	0.000	-0.9748	-0.5691
	Landlocked	0.3489	0.0923	3.78	0.000	0.1681	0.5297
	CommonLanguage	-0.1725	0.1421	-1.21	0.225	-0.4510	0.1060
	CommonColonizer	0.3890	0.1017	3.83	0.000	0.1897	0.5883
	Contiguity	-0.7785	0.1794	-4.34	0.000	-1.1302	-0.4269
	FTA	0.4523	0.1351	3.35	0.001	0.1875	0.7172
	LnAir	0.0254	0.0030	8.49	0.000	0.0195	0.0313
	Religion	0.3929	0.1334	2.94	0.003	0.1314	0.6544
	Constant	-2.9903	1.2310	-2.43	0.015	-5.4030	-0.5775
	/athrho	0.0684	0.1123	0.61	0.542	-0.1517	0.2885
	/lnsigma	0.7865	0.0188	41.76	0.000	0.7496	0.8234
	rho	0.0683	0.1118			-0.1505	0.2885
	sigma	2.1958	0.0414			2.1162	2.2783
	lambda	0.1500	0.2459			-0.3320	0.6319
	LR test of indep. Eqns. (rho = 0): chi2(1) = 0.35 Prob>chi2 = 0.5559						

Appendix 11: Case study for top and bottom performers in rail transport infrastructure

Dep: Exports	Rail – Best Performers		Rail – Worst Performers	
Model	**1**	**2**	**1**	**2**
Log (distance)	omitted	omitted	omitted	omitted
Log (GDP) reporter	2.8168*** (1.0768)	2.7733** (1.1159)	-10.145*** (2.9003)	-10.1811*** (2.9080)
Log (GDP) partner	3.0443** (1.2268)	3.0647** (1.1829)	10.271*** (2.8316)	10.3031*** (2.8377)
Landlocked	omitted	omitted	-20.6137*** (7.4766)	-17.8958*** (5.9789)
common language	omitted	omitted	omitted	omitted
common colonizer	omitted	omitted	omitted	omitted
contiguity	omitted	omitted	omitted	omitted
FTA	omitted	omitted	omitted	omitted
Log (Rail) reporter	-0.5778** (0.2432)		-12.6375*** (4.7838)	
Log (Rail) partner	-0.4774* (0.2680)		-9.2014*** (2.8335)	
Log (Rail)	pair	-0.063*** (0.197)		-1.6212*** (0.4928)
Constant	-123.418** (60.8355)	-127.246** (60.3157)	154.7792*** (44.3002)	80.3331*** (28.9490)

Appendix 12: Case study for top and bottom performers in maritime (liner) transport

Dep: Exports	Liner – Best Performers		Liner – Worst Performers	
Model	**1**	**2**	**1**	**2**
Log (distance)	-3.1542*** (0.5781)	-3.3320*** (0.5044)	-2.6803*** (0.3484)	-2.6735*** (0.3557)
Log (GDP) reporter	0.7274* (0.3869)	0.3437 (0.2814)	0.9910*** (0.2435)	1.0040*** (0.2442)

Log (GDP) partner	0.0176 (0.4020)	0.0757 (0.2859)	0.2129* (0.1264)	0.2085* (0.1203)
Landlocked	omitted	Omitted	Omitted	Omitted
Common language	-1.2857 (0.8921)	-1.4917* (0.8093)	-2.9164*** (0.5709)	-2.8746*** (0.5356)
Common colonizer	1.5584* (0.9088)	1.6714** (0.7902)	-1.3045*** (0.3831)	-1.2967*** (0.3843)
Contiguity	Omitted	Omitted	Omitted	Omitted
FTA	-0.1085 (0.5964)	-0.0967 (0.4603)	omitted	Omitted
Liner reporter	-0.0155 (0.0188)		-0.0428 (0.0.0319)	
Liner partner	0.0085 (0.1783)		-0.0661 (0.0665)	
Liner pair		0.0002425 (0.00443)		-0.0065* (0.0037)
Constant	24.5262 (19.0892)	33.7601*** (12.3848)	12.2800* (6.5260)	11.5402* (6.5398)

Appendix 13: Case study for top and bottom performers in air transport

Dep: Exports	**Air – Best Performers**		**Air – Worst Performers**	
Model	**1**	**2**	**1**	**2**
Log (distance)	2.1977*** (0.5343)	1.9669*** (0.5378)	-1.9541*** (0.4429)	-2.3434*** (0.4827)
Log (GDP) reporter	0.6032*** (0.1057)	0.6647*** (0.1164)	-0.7335** (0.3831)	-0.6968* (0.3913)
Log (GDP) partner	0.4832*** (0.1053)	0.3609*** (0.0891)	-0.1138 (0.3980)	0.3030 (0.4215)
Landlocked	-2.2132*** (0.1888)	-1.9718*** (0.1412)	-1.2980*** (0.4519)	-0.6854 (0.4249)

Common language	4.7113*** (0.5137)	4.5535*** (0.5004)	5.4456*** (1.2808)	4.4208*** (0.1555)
Common Colonizer	3.6125*** (0.3415)	3.5284*** (0.3209)	-2.3583** (1.1343)	-2.0058* (1.0736)
Contiguity	2.6602*** (0.5646)	2.5280*** (0.5809)	Omitted	Omitted
FTA	-3.2893*** (0.3946)	-3.0178*** (0.3547)	omitted	Omitted
Log (Air) reporter	0.3655*** (0.1242)		-0.2036 (0.1459)	
Log (Air) partner	-0.2448** (0.1161)		0.3532* (0.1965)	
Log (Air) pair		0.0060 (0.0045)		0.0145 (0.0130)
Constant	-28.4764*** (9.0119)	-24.6358*** (8.8234)	14.9044*** (14.2852)	38.2626** (15.2901)

The Effect of COMESA Free Trade Agreement on Intra-COMESA Trade Efficiency

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Abstract

This study used a Stochastic Frontier Gravity Model (SFGM) to assess the evolution of intra-COMESA merchandise trade efficiency of Member States from 1997 to 2020 and thereafter evaluated the effect of the Common Market for Eastern and Southern Africa (COMESA) Free Trade Agreement (FTA) on trade efficiency. The findings indicate that intra-COMESA trade is influenced by rising income levels in Member States and Foreign Direct Investment (FDI), common language and a higher population of the exporting country. However, larger distance between trading partners discourages intra-COMESA trade due to high transport costs. The study also found that there is room for COMESA Member States to trade more with each other as the intra-trade efficiency averaged only 0.56 over the study period. However, the study found that COMESA FTA has contributed to improvement in the intra-COMESA trade efficiency, averaging 0.40 in the period 1997-2000 and increasing to 0.45 in the period (2001-2005) after the FTA implementation, and further to about 0.60 in the period 2011 to 2020. To boost intra-COMESA trade efficiency, the study recommends: COMESA Secretariat enhance efforts to reduce non-tariff barriers to trade and increase trade facilitation to enhance efficiency; encourage non-participating COMESA Member States to join the COMESA FTA given its role in enhancing their intra-trade efficiency; Member States to strengthen trade partnerships with nearby countries with fast expanding economies and markets to enhance trade performance; and promote financial deepening and broadening by increasing provision of financial services through wider choices of financial services and better access for different socioeconomic groups which enhances credit access and liquidity thereby favouring more trade.

1 Introduction

1.1 Introduction and Background

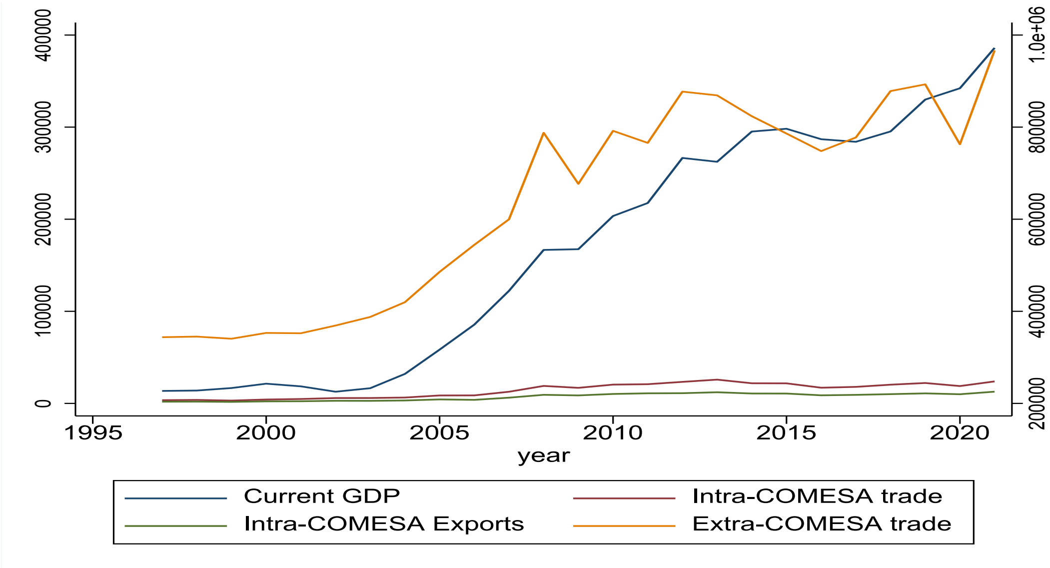
Regional integration has been a pivotal force in globalization over the past six decades by enabling the movement of goods, services, finance, and people across national borders (COMESA, 2021). It facilitates international trade between countries and serves as a crucial driver of productivity and economic development. International trade boosts economic growth by increasing competitiveness. Governments across African countries are implementing initiatives aimed at enhancing regional integration to facilitate easier movement of goods, services, and people. The Common Market for Eastern and Southern Africa (COMESA) comprising 21 Member States, has developed several initiatives pertaining to trade liberalization: creating a Free Trade Area (FTA) by abolishing tariffs and non-tariff barriers (NTBs), including removing import and export quotas, simplifying customs formalities, among others. More specifically, to strengthen trade integration, COMESA has designed and implemented various trade integration programs and instruments related to the free trade agreement, trade facilitation, and transit facilitation.

Many countries have used bilateral or multilateral FTAs to increase trade. The World Trade Organization (WTO) reported that there were 259 Free Trade Agreements (FTAs) active as of 2014, including the COMESA FTA. COMESA was formed in December 1994 to replace the Preferential Trade Area (PTA) which existed from 1981. In October 2000, the COMESA Free Trade Area (FTA) was established when nine Member States abolished tariffs on products originating from COMESA, following the tariff reduction schedule adopted in 1992. This followed years of progressive trade liberalization launched in 1984 (COMESA, 2018). Burundi and Rwanda became FTA members in 2004, making 11 members that have abolished customs tariffs and are working on eliminating non-tariff barriers. As of 2022, the FTA included 16 countries, with DR Congo, Ethiopia, Eritrea, and Somalia in various stages of joining. Eswatini is under derogation awaiting implementation of the Tripartite Free Trade Area. The COMESA Rules of Origin determine eligibility for preferential treatment under the FTA (COMESA, 2018).

The FTA has substantially lowered tariff and non-tariff barriers in the region, greatly facilitating COMESA exports and enhancing the countries' trade potential and efficiency (Geda and Kebret, 2008; Elbushra et al. 2011). In this context, trade potential is the highest possible total trade value with optimal trade policies, while trade efficiency measures the difference between actual and potential trade flow (Jomit, 2014). COMESA's trade volume increased substantially over the last decade, boosting the region's economic growth.

Figure 1 shows the trend in intra and extra-COMESA trade, intra-COMESA exports and Gross Domestic Product (GDP) in current prices for the region from 1997 to 2021. From the figure, it is clear that both COMESA intra-trade and external trade experienced an upward trend, especially after the start of COMESA FTA. Particularly, intra-COMESA merchandise trade grew from US$4.3 billion in 2000 to US$23.9 billion in 2021, with intra-exports alone increasing from US$ 2.3 billion in 2000 to US$ 12.8 billion in 2021. Similarly, COMESA's merchandise trade with the rest of the world grew from US$76.6 billion in 2000 to US$383.4 billion in 2021. This was accompanied by an increase in COMESA's GDP (current prices) from US$242.9 billion in 2000 to US$972.1 billion in 2021. These trends indicate a positive correlation between intra- COMESA merchandise trade, extra-COMESA trade and COMESA GDP especially after the start of COMESA FTA.

Figure 1. Trends in intra and extra-COMESA merchandise trade, intra-COMESA exports and GDP in US$ millions.



***Source**: Authors' computation using COMSTAT and UNCTADstat*

However, despite the phenomenal growth, intra-COMESA trade remains below the extra-COMESA trade and intra-COMESA exports account for approximately 8 percent of COMESA's global exports. For example, COMESA had an intra-export potential of US$ 101.1 billion as of 2019 (COMESA, 2021). Given that COMESA is an open region, if at least half of the extra- COMESA exports were channeled within the region, then the intra-COMESA exports could rise by at least US$90.2 billion from the actual realized of US$ 10.9 billion in 2019. This would in turn increase total merchandise trade in the region. This study therefore examines the evolution of the efficiency of intra-COMESA merchandise trade and the determinants of trade efficiency in general. In particular, the role of the COMESA FTA is emphasized in examining to what extent the FTA has affected trade efficiency.

1.2 Statement of the Problem

Trade, through exports and imports, links markets of COMESA countries with producers and consumers, playing a crucial role in financial, technological, and service flows necessary to achieve the development objectives of COMESA countries. The trend discussed in section 1.1 (Introduction and Background of the study) indicates a sharp increase in intra-COMESA merchandise trade since the introduction of the COMESA FTA. However, despite the region's significant comparative advantage in supplying minerals like nickel ores and concentrates, unrefined copper, industrial diamonds, and natural gas, both within the region and globally, the overall intra-COMESA exports have remained below its potential. For example, in 2019, COMESA identified an intra-COMESA exports potential of about US$ 101.1 billion.[16] This raises concerns about the performance of the intra-COMESA trade and the extent to which the free trade agreement has contributed to trade efficiency in COMESA Member States.

16 This could be attributed to poor infrastructure connectivity, high transport cost, high bank charges and weak productive capacities in Member States especially in areas of human capital, structural changes, energy and Information Communication Technology.

Studies have been conducted on the link between free trade agreements and trade efficiency globally.[17] However, economic literature offers differing views. Supporters of trade openness argue that free trade enhances production efficiency, productivity, and welfare across countries, sectors, and firms. [18]Conversely, macroeconomic research suggests that free trade can lead to inefficiencies due to institutional and market frictions, affecting resource allocation, employment access, and overall productivity across firms. Given these conflicting facts, the following question arises: do regional trade agreements affect the trade efficiency of COMESA Member States? Understanding this will reveal whether trade integration does or does not increase trade efficiency among COMESA Member States. It is essential for each country to realize its full potential with its partners and other sectors, in order to improve trade flows and the well-being of its people.

1.3 Study Objectives

The general objective of the study is to determine the effect of COMESA Free Trade Agreement on intra-trade efficiency. The specific objectives are:

i. To assess the evolution of the efficiency of intra-COMESA trade;
ii. To determine the extent to which COMESA's FTA has contributed to trade efficiency in COMESA Member States;
iii. To identify key constraints and challenges hindering intra-COMESA trade.

1.4 Significance of the Study

The study is founded on the concern that COMESA, like other regional economic communities, has persistently experienced low intra-regional trade. Despite the progressive increase, intra-COMESA exports account for only 8 percent of global exports. This is at the backdrop of research showing that the region has intra- export potential of US$ 101.1 billion using the 2019 statistics (COMESA, 2021). This persistence in limitation in intra-COMESA trade is a cause for concern as great efforts have been placed to economically integrate the region, promote the development of natural and human resources for the shared benefit of all and generally making the region attractive.

Conversely, COMESA (2021) reports that the regional bloc is facing challenges that hinder the full exploitation of its trade potential, including inadequate infrastructure connectivity, elevated transport costs, incomplete or delayed implementation of COMESA FTA agreement, non-tariff barriers, and trading in similar products, among others. This study comes in handy to analyze, how the COMESA FTA has so far impacted intra-COMESA trade efficiency.

2 Review of Literature

2.1 Theoretical Review

The first theory that attempted to understand the efficiency of trade was Ricardo's Theory of

17 See for example Haveman and Hummels (2002); Chauvin and Gaulier (2002); Khandelwal (2004); Pastore et al. (2009); Stack and Pentecost (2011); Bhattacharya & Das (2014); Ravishankar and Stack (2014) and Tamini et al. (2016).

18 See Hsieh and Klenow (2009).

Comparative Advantage in 1817 (Ricardo,1817). According to this theory, free trade requires that each country focuses on producing goods for which it has the highest productivity compared to its partners. This theory was the basis of the Hecksher-Ohlin model introduced in the 1930s. This model was one of the first to use differences in resource endowments between countries to explain specialization and efficiency in international trade. Therefore, to become more efficient with openness, a country must either specialize in products for where it has technological comparative advantage over its partners, shift its production to industries that utilize the country's relatively abundant factors most intensively or direct its production towards products that have economies of scale in production. The theories of comparative advantage and factor endowments explain inter-sectoral trade between nations producing similar products, but they do not cover a significant part of international flows where trade between two countries takes place between differentiated goods produced by the same industrial sectors. In addition, the theory ignores all other non-labour costs involved in the production of goods like transport costs. In theoretical literature, Paul Krugman (1980), Bernard and Jensen (1999), Ottaviano and Melitz (2005) and Redding and Schott (2007) have developed models of intra-industry trade. These studies show that when there are transport costs, the price of exports will increase even if the countries have an advantage in factor endowments. Thus, if production costs are similar across countries, it will be more efficient to produce near the largest market to minimize transportation costs and to exploit the gains from economies of scale. This research also shows that exporting firms differ greatly from non-exporting firms in terms of efficiency. Because of internationalization and intense competition in the world market, they are more productive and employ human and physical capital more efficiently and intensively.

Most of these studies have used the conventional gravity model of Tinbergen (1962). It measures bilateral trade flows between two partners and predicts the trade volume based on the economic weight of two countries and the physical distance between them. The equation states that the attraction between two economies is proportional to the product of their mass and decreases with distance. It is formalized as follows:

$$X_{ij} = A\frac{Y_i^{\alpha}Y_j^{\beta}}{D_{ij}^{\vartheta}} \qquad (1)$$

In the equation, X_{ij} represents the volume of trade measured by the respective exports of COMESA country i and trading partner j. Y_i and Y_j are the respective GDPs, D_{ij} the distance between these countries. α, β and ϑ are the respective elasticities of these variables.

Traditional gravity models typically estimate trade determinants' average effects using actual trade volumes. However, as Kalirajan and Findlay (2005) point out, real trade volumes are always less than the maximum level due to natural and artificial resistances. This implies the presence of error terms with positive averages that can measure the gap between real and potential trade. Armstrong (2007) proposed a stochastic gravity equation to address these limitations:

$$X_{ijt} = f(Y_{ijt};\beta)exp^{(v_{ijt}-u_{ijt})} \qquad (2)$$

where (X_{ijt}) captures COMESA Member States's i exports with trading partner j at year t, (X_{it}) captures factors determining potential trade, and β represents a vector of unknown parameters, to be estimated. Both μ_{ijt} and v_{ijt} are error terms. While v_{ijt} captures random shocks, μ_{it} captures efficiency loss, i.e., the magnitude of inefficiency of COMESA country's i trade with trading partner j.

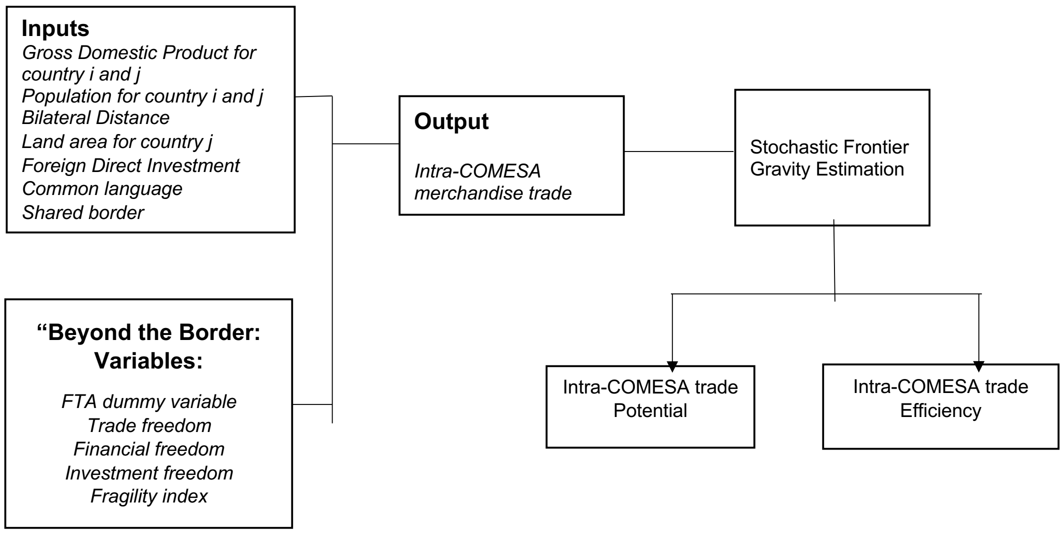
From the above equation, the trade efficiency with a particular trading partner j is represented as follows:

$$TEX_{ijt} = \frac{f(Y_{ijt};\beta)\exp(v_{ijt} - u_{ijt})}{f(T;\beta)\exp(v_{ijt})} = \exp(-u_{ijt}) \qquad (3)$$

where $f(Y_{ijt};\beta)\ exp(v_{ijt}-u_{ijt})$ represents actual exports and $f(T,\beta)\ exp(v_{ijt})$ represents the highest possible export volume by COMESA country i to trading partner j. A higher TEX_{ijt} implies greater efficiency, or an export volume closer to the export frontier.

The Conceptual Framework of the SFGM and variables are presented in Figure 2.

Figure 2. Estimation Framework of Stochastic Frontier Gravity Model.



***Source**: Authors' compilation.*

2.2 Empirical Review

Empirically, literature analysing the factors influencing trade efficiency is vast. Analyses based on gravity models have been extensively employed to elucidate bilateral trade flows and trade efficiency (for example Haveman and Hummels (2004) who used Heckscher-Ohlin simulated data and real bilateral trade, Chauvin and Gaulier (2002) using Southern African Development Community (SADC) data, Khandelwal (2004) who focused on SADC and COMESA regions, Pastore et al. (2009) for the European Union (EU) in the period 1995 to 2002, Stack and Pentecost (2011) for EU and the Organization for Economic Co-operation and Development (OECD) states, Ravishankar and Stack (2014) for the Eastern-Western European Countries in the period 1994-2007, Bhattacharya and Das (2014) for the South Asian Association for Regional Cooperation (SAARC) between 1995 and 2008, Tamini et al. (2016) for the North Africa countries in the period 2001-2012, among others). Overall, the results of these studies show that trade inefficiencies and frictions are empirically related to factors such as, legal systems and monetary policy differences especially monetary regimes, languages, trade policy such as tariffs, competitive policies, and other discriminatory restrictions on foreign producers are also factors that determine efficiency in bilateral trade.

Stack and Pentecost (2011) employed the SFGM for 20 OECD trading partners with the European Union countries over the period 1992 to 2003. They projected potential trade for 10 new Member States and 10 associated countries using an out-of-sample approach. Results indicated future trade growth for the new Member States, while Mediterranean countries showed limited opportunities for trade expansion within the EU.

Bhattacharya and Das (2014) employed the SFGM to study intra-trade performance in South Asian Association for Regional Cooperation (SAARC), exploring "behind the border" and "beyond the border" constraints and the synergy between trade and development goals in the region. They found that weak institutions are significant barriers to trade efficiency and that weak institutions remain significant barriers to trade efficiency in SAARC despite the significant potential to improve trade complementarities among its members.

Tamini et al. (2016) assessed actual and potential trade among North African trading partners from 2001 to 2012 and found Mauritania to have the least efficient trading relationship both as a destination and origin. Tunisia and Morocco faced fewer trade barriers.

Al-Atrash and Yousef (2000) based their analysis of trade efficiency on 18 Arab countries in trade with 43 partners between 1995 and 1997 and employed SFGM. Unlike in other regions where a common language facilitates trade flows, they found that a similar culture, which was measured by whether countries spoke the same language, had a mixed effect on trade flows in the Arab region. Following the same logic, Abdmoulah (2011) focused on Arab trade integration over the period 1997-2008 and found that, in addition to other factors such as market size and bilateral distance, the performance of Arab trade integration was also influenced by whether trading partners had similar Colonizers. The analysis employed a zero-inflated negative binomial gravity model. Surprisingly, the authors also found that the trade agreements, apart from the Greater Arab FTA, with the Arab regions did not encourage trade.

The findings of Ebaidalla and Mohammed (2023) corroborate earlier research, highlighting the primary determinants of trade: GDP, economic size, and geographic distance. Their study employed a two-stage SFGM and focused on intra-Arab trade integration between 1998 and 2015. However, they noted that while core variables are crucial for trade flows, trade efficiency largely depends on the strength of institutions behind the border. Stronger institutions reduce trade inefficiencies, even with numerous trade agreements in place.

The launch of "One Belt, One Road" has attracted a lot of researchers' attention, aiming to find out whether connectivity and infrastructure improve trade flows and trade efficiency. Wang and Chen (2019) and He et al. (2013) found that the China-India-Mynmar Economic Corridor created shipping efficiency which improved trade efficiency. Similarly, Herroro and Xu (2017) argue that the improvement of cross-border infrastructure was one of the key ingredients that improved trade efficiency through its ability to reduce transport costs even when trading partners were miles apart. Apart from these factors, other researchers have underscored the need for trade facilitation (Gao and Tian, 2019; and Zhou, 2017 - China) and trade integration (Ravishankar and Stack, 2014 - East West trade) to improve trade efficiency. Researchers argue that the former improves trade efficiency by enhancing competitiveness and reliability. On the other hand, trade integration creates greater market access, reduces trade costs, and reduces trade barriers that could result from trade resistance. Studies by Fan and Huang (2017) and Peng et al. (2020) pointed out that cultural distance negatively impacts trade efficiency, while Liu and Wang (2017) showed that a favourable institutional environment improves trade efficiency by strengthening policy coordination.

A few cross-country analyses have also been conducted in the literature. For example, Deluna and Cruz (2013) employed the SFGM to estimate the export potential and efficiency of the Philippines' 69 trading partners from 2009 to 2012. They found that higher income and market size of importing partners boost export flow, while bilateral distance hinders it. The results of the inefficiency model reveal that membership in the Association of Southeast Asian Nations (ASEAN), Asia-Pacific Economic Cooperation (APEC), WTO, common language, and reduced corruption increase export potential. Elbushra et al. (2011) found that Sudan's membership in COMESA's FTA promotes its agricultural exports within the region. Similarly, Edeme et al. (2022), using data from 45 African countries between 1996 and 2018, showed that African FTAs positively impact agricultural exports, though the effect is not immediate.

Few studies have analysed COMESA's trade performance in the global trading system. Hussein (2008) used a Tobit gravity model to assess Ethiopia's exports from 1981 to 2006, finding that COMESA membership had minimal impact on export flows. Khandelwal (2004) explored trade expansion in COMESA and SADC, highlighting that while COMESA focuses on market liberalization, it faces implementation challenges. He also noted limited potential for increasing intra-regional trade but both trade agreements provide opportunities for adopting credible reform policies. Ebaidalla and Yahia (2014) compared intra-COMESA trade integration to ASEAN, using a two-stage empirical gravity model. They found that COMESA Member States are trading below their potential, though the gap is closing over time, indicating progress toward potential trade levels.

2.3 Overview of Literature

Several gravity model-based studies have investigated the determinants of bilateral trade flows, free trade areas and trade efficiency in both developed and developing countries alike (Al-Atrash and Yousef (2000); Khandelwal (2004); Hussein (2008); Abdmoulah (2011); Elbushra et al. (2011); Bhattacharya and Das (2014); Ebaidalla and Yahia (2014); Liu and Wang (2017); Wang and Chen (2019); Edeme et al. (2022); Ebaidalla and Mohammed (2023)). The majority of these studies indicate that trade inefficiencies stem from constraints both within and beyond national borders. The studies vary significantly in terms of the countries sampled, which include developed, developing, or emerging economies, as well as cross-country analyses. They also differ in their model specifications, including the explanatory factors considered, and in the representation of the key variable, trade. However, only a limited number of studies have focused on the COMESA region. Furthermore, the few that consider the COMESA region are single country analyses, for example, the study on Ethiopia by Hussein (2008) and Sudan Elbushra et al. (2011) or conduct regional comparisons such as the studies by Khandelwal (2004) or Ebaidalla and Yahia (2014). Therefore, the study's contribution to the existing body of knowledge is threefold: it examines the evolution of intra-COMESA trade efficiency, analyses how the COMESA FTA has impacted intra-trade efficiency since its implementation in 2000 and lastly, it identifies other key challenges that hinder intra-COMESA trade efficiency.

3 Methodology

3.1 Model Specification

This study attempts to assess the evolution of the efficiency of intra-COMESA merchandise trade and establish the factors that play a role in shaping this efficiency. In particular, it emphasizes determining the role COMESA FTA plays on influencing trade efficiency. To this end, the analysis is divided into two parts. In the first part, it estimates the intra-COMESA trade efficiency frontier using the stochastic frontier gravity model introduced in equation 1. Imposing the variables suggested from the literature review and the conceptual framework described in Section 2, the equation can be re-written as:

$$lntrade_{ijt} = \beta_0 + \beta_1 lnGDP_{it} + \beta_2 lnGDP_{jt} + \beta_3 lnDIST_{ij} + \beta_4 lnAREA_j + \beta_5 lnPOP_{jt} + \beta_6 lnPOP_{it} + \beta_7 lnFDI_{it} + BORDER_{ijt} + LANG_{ijt} - u_{ijt} + \varepsilon_{ijt} \quad (4)$$

where:

$Trade_{ijt}$ is the total trade between COMESA Member States i and j at time t .

GDP_{it} and GDP_{jt} represent the GDP of the exporting country i and importing country j respectively at time t. Larger nations generally engage in more trade, which aligns with the significant amount of intra-industry trade among between developed countries (Helpman and Krugman 1985). Consequently, the GDP coefficients for both countries are expected to exhibit a positive sign.

POP_{jt} is the population of the importing country j at time t. As suggested by Brada and Méndez (1985), a big population in an importing country improves the competition between imported goods and domestic products and for this reason, this variable is included.

POP_{it} is the population of the exporting country i at time t. It is considered a key driver of trade, as it indicates the balance between absorption and economies of scale. On one hand, Endoh (1999) argues that an exporting nation with a big population may lead to more product variety and less reliance on foreign trade. Conversely, when a country has a large home market, it might leverage economies of scale to expand trade activities with partners resulting in an anticipated positive sign (Kien, 2009).

$DIST_{ij}$ is the geographical distance between trading partners i and j main cities, measured in kilometers. Because the cost of delivering products grows with physical distance, the distance coefficient is expected to be negatively signed.

$AREA_j$ is the land area of importing country j measured in square kilometers.

FDI_{it} is Foreign direct investment, which significantly promotes trade particularly exports of the host countries (UNCTAD, 2002)[19]. Many global enterprises leverage host countries' inexpensive labour and finished goods for export to their home markets. FDI can boost export volume to the FDI source countries, influencing cross-country trade efficiency differences (Zhang,2005). This variable is expected to augment trade potential.

$BORDER_j$ is a dummy variable that equals 1 if the trading partners share a common border and 0

19 The United Nations Conference on Trade and Development.

otherwise.

$LANG_{ij}$ is a dummy variable that equals 1 if the trading partners share a common language and zero otherwise.

E_{ijt} is the stochastic error term assumed to be *iid* such that v_{it} ~ *N(0,σ_v^2)*..

u_{ijt} captures the inefficiency term (trade inefficiency), a non-negative random variable derived from truncating the normal distribution at zero.[20] The trade frontier represents the highest attainable level of trade a COMESA Member State can achieve with other COMESA trading partners given a set of factors. The Stochastic Frontier Analysis (SFA) simultaneously estimates the trade capacity using factors under its control u_{ijt} and beyond it, E_{ijt}

Trade efficiency scores are predicted using Jondrow et al. (1982) formula based on the observable value of as follows: u_{ijt}

$$TE_{ijt} = \frac{X_{ijt}}{\exp\,(K'_{ijt}\beta + \varepsilon_{ijt})} = \frac{\exp\,(K'_{ijt}\beta + \varepsilon_{ijt} - u_{ijt})}{\exp\,(K'_{ijt}\beta + \varepsilon_{ijt})} = \exp\left(-u_{ijt}\right) \qquad (5)$$

Using the results of equation 5, the technical efficiency (trade efficiency) equation with trading partner j is specified as follows:

$$TE_{ijt} = \delta_0 + \delta_1 FTA_t + \delta_2 TF_{it} + \delta_3 IF_{it} + \delta_4 FF_{it} + \delta_5 FRAG_{it} + \beta_6 WTO_{it} + \omega_{it} \qquad (6)$$

where:

TE_{ijt} is the trade efficiency of COMESA Member States i with respect to trading partner j at time t.

FTA_{it} is a dummy variable to identify the period when 16 COMESA Member States enjoyed a Free Trade Agreement. In October 2000, all but two COMESA countries eliminated all internal trade barriers to form an FTA. Therefore, a dummy variable that equals 0 for 1997-2000 and 1 in the period 2001-2020 is used to capture the effect of an FTA on intra-COMESA trade efficiency. A positive coefficient is expected, implying the FTA helped to improve trade efficiency.

TF_{it} is the trade freedom index of country i at time t, which measures the absence of tariff and non-tariff barriers in home country i, including quantity, price, regulatory, investment, customs restrictions, and direct government intervention. The score ranges between 0 and 100; higher scores indicate fewer trade barriers.

FF_{it} is the financial freedom index of country i at time t . It measures banking efficiency and independence from government control in the financial sector. The index ranges 0 to 100, with higher values indicating greater financial freedom.

IF_{it} is the investment freedom index of country i at time t , indicating how freely investment capital flows. A higher score means freer movement of investments within and across the country's borders.

$FRAG_{it}$ measures a country's state capacity to handle conflicts, establish and implement public

20 Greene (2008) observed that assumptions regarding the inefficiency term's distribution (exponential, half-normal, or truncated-normal) have little effect on inefficiency estimates. Coelli et al. (2005) suggest using a more general distribution like the truncated-normal distribution.

policy without any breaks in public service delivery, respond effectively to challenges and crises, and sustain progressive development. The index lies between 0 and 25, and higher scores are associated with better state capacity to handle conflict.

WTO_{it} is a dummy variable that represents whether a COMESA Member State is a member of the WTO, with a value of 1 indicating membership after joining the WTO.

W_{it} captures random shocks.

3.2 Estimation Technique

As described in section 3.1, the trade efficiency scores are estimated using the stochastic frontier approach of the gravity model methodology proposed by Drysdale et.al. (2000) and Kalirajan and Finley (2005). Equation 2 follows a Cobb-Douglas form and is only linear in logs. Therefore, except for the dummy variables, all variables in equation 4 are in their natural logarithmic (ln) form. The estimation uses the Battese and Coelli (1995) parametrization with the Maximum Likelihood random-effects time-varying inefficiency effects estimator, assuming a truncated normal distribution for the inefficiency term.

Subsequently, the static panel specification in equation 5 where the role of the COMESA FTA on trade efficiency is investigated is estimated using Fixed effects (FE) method with robust standard errors. This is after conducting the Hausman test that was in favour of a Fixed Effect over a Random Effect model. FE mitigates heterogeneity bias from correlations between regressors and country-specific effects by accounting for unobserved effects tied to the error term (Greene, 2012).

3.3 Scope and Data

The study utilizes panel data consisting of 16 COMESA Member States that are implementing the FTA agreement for intra-COMESA total trade from 1997 to 2020. The variables employed in the stochastic frontier gravity model include intra-COMESA total merchandise trade (TRADE), Gross Domestic product (GDP) for both trading partners, population size (POP) for both trading partners, foreign direct investment (FDI), bilateral distance (DIST), the land area of the importing trading partner (AREA), shared border (BORDER) and common language (LANG). The aggregate data on merchandise trade was obtained from COMESA's COMSTAT data hub. Data on GDP and population as proxies for economic development and market size respectively, and FDI were taken from the World Bank's World Development Indicators (WDI). Data on bilateral distance measured in kilometers, land area measured in square kilometres, shared border and common language were acquired from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) database by Mayer and Zignago (2011).

In the subsequent analysis where we assess the extent to which FTA influences intra-COMESA's trade efficiency, the study includes the following explanatory variables: a dummy variable to represent the period of FTA implementation (FTA), investment freedom (IF), financial freedom (FF), foreign direct investment (FDI), fragility index (FRAG) and WTO membership (WTO). To check the robustness of the analysis, the study employs trade freedom (TF) as an alternative to assess the impact of the COMESA FTA on intra-COMESA trade efficiency. The trade freedom (TF) index measures the absence of trade barriers in the home country. It ranges from 0 to 100, with higher scores indicating fewer trade barriers. These indices are obtained from the Economic Freedom dataset (EF) by the Heritage Foundation and Quality of Government (QoG) database respectively. A concise description of the variables, their measurement and sources are provided in Table 1.

Table 1. Variable description, measurement and sources

Variable	Description	Source
Intra-COMESA trade	Total merchandise trade between COMESA Member States measured in millions of US$	COMSTAT
GDP	GDP at 2015 constant US$ prices	WDI
FDI	Foreign direct investment of exporting country measured in millions of current US$	WDI
Distance	Geographical distance between trading partners' main cities, measured in kilometers	CEPII
Population	Population of the Member State measured in millions	WDI
Area	Land area of importing country measured in square kilometers	CEPII
Shared border	Dummy variable which equals 1 if the trading partners share a common border and 0 otherwise	CEPII
Common language	Dummy variable which equals 1 if the trading partners share a common language and zero otherwise.	CEPII
Trade freedom	Measures the absence of tariff and non-tariff barriers in home country i, including quantity, price, regulatory, investment, customs restrictions, and direct government intervention. The score ranges between 0 and 100; higher scores indicate fewer trade barriers.	Economic Freedom
Investment freedom	Measures banking efficiency and independence from government control in the financial sector.	Economic Freedom
Financial freedom	Measures how freely investment capital flows. A higher score means freer movement of investments within and across the country's borders.	Economic Freedom

Fragility index	Measures a country's state capacity to handle conflicts, establish and implement public policy without any breaks in public service delivery. Index lies between 0 and 25, and higher scores are associated with better state capacity to handle conflict.	Quality of Government
FTA dummy	Dummy variable to identify the period when 16 COMESA Member States enjoyed an FTA benefits	Authors' computation
WTO dummy	Dummy variable that represents whether a COMESA Member State is a member of the WTO, with a value of 1 indicating membership after joining the WTO.	WTO
Trade efficiency	Trade efficiency of COMESA Member States	Authors' computation

4 Presentation and Discussion of Results

4.1 Descriptive Statistics

Descriptive characteristics summarize the data for the 16 COMESA Member States for the period 1997 to 2020. The results show that total intra-COMESA trade and GDP averaged US$ 715 million and US$ 37.9 billion respectively. However, they both displayed large dispersion as shown by the standard deviation of US$ 921 million and US$ 68.2 billion respectively. A large standard deviation suggests large variations in intra-trade and economic development of the COMESA Member States. A summary statistic of the variables employed in the study is provided in Table 2.

Table 2. Summary of descriptive statistics

Variable	Obs	Mean	SD	Min	Max
Intra-COMESA trade	5760	7.15e+08	9.21e+08	484633	4.60e+09
GDP	5490	3.79e+10	6.82e+10	5.60e+08	4.10e+11
FDI	5760	3.276	4.644	-1.304	57.877
Distance	5760	2798.556	1511.557	180.006	7545.616
Population	5760	2.16e+07	2.46e+07	77319	1.10e+08
Area	5760	647908	815536.1	455	2505813
Shared border	5760	0.138	0.344	0	1
Common language	5760	0.55	0.498	0	1
Trade freedom	4920	62.341	15.839	0	90
Investment freedom	4980	44.398	19.853	0	90
Financial freedom	4860	40.586	17.339	10	70
Fragility index	4950	15.118	5.478	0	24
FTA dummy	5760	0.833	0.373	0	1
WTO dummy	5760	0.766	0.424	0	1
Trade efficiency	5224	0.555	0.196	0.001	0.872

***Source**: Author's computation from the study data*

4.2 Panel Unit Root Tests

Unit roots tests conducted using Fisher's Phillips-Perron (PP) method, are presented in Table 3. This test is preferred to Augmented Dickey Fuller (ADF) test due to its robustness when it comes to dealing with serial correlation that may arise with the use of lags of the variables, and ability to handle gaps in panel data. The tests included both trend and no-trend scenarios. Results showed stationarity without a trend at one percent levels of significance for all the variables.

Table 3. Panel unit root test

Variables	Phillips-Perron (PP) test At Levels Constant	Remarks
Ln intra-COMESA trade	1471.690***	Stationary
Ln GDP	659.590***	Stationary
Ln FDI	1643.662***	Stationary
Ln population	2528.0589***	Stationary
Ln trade freedom	1777.3712***	Stationary
Ln investment freedom	697.2489***	Stationary
Ln financial freedom	768.650***	Stationary
Ln fragility index	510.555**	Stationary
Trade efficiency scores	2405.992***	Stationary

***Source**: Author's computation from the study data*

4.3 Specification Tests

To analyse the role of COMESA FTA in intra-COMESA trade, we conducted the Hausman's Specification Test to choose between fixed effect (FE) and random effect (RE) model. As shown in Table 4, the RE model was rejected, hence the study estimated the FE model. In addition, the Wooldridge test for autocorrelation in panel data and the Wald test for group wise heteroscedasticity were carried out and the results are presented in Table 4. Heteroscedasticity, autocorrelation and cross-sectional dependence issues were detected and solved using robust standard errors in the baseline analysis and FE estimation with Driscoll-Kraay standard errors as a robustness check.

Table 4. Specification Tests

Specification Test	Null hypothesis	p-value
Hausman F-test for FE versus RE models	H0: RE model is consistent	0.0000
Serial correlation	H0: No serial correlation	0.0000
Heteroscedasticity	H0: Homoscedasticity	0.0000
Cross-sectional dependence Pesaran's CD test	H0: No cross-sectional dependence	0.0000

4.4 Discussion of Intra-COMESA Trade Efficiency

In this section, the findings of the Stochastic Frontier Gravity Model are discussed. The first objective of the study was to assess the evolution of the efficiency of intra-COMESA merchandise trade and identify factors that influence trade efficiency in general. Table 5 shows the frontier model results. The second model (column 2) includes additional determinants of trade, "beyond the border" variables, that influence trade performance and are considered our baseline model.

The table indicates that the coefficients of the GDP of both the importing and exporting countries are positive and significant at 1 percent level of significance. The GDP coefficient of 0.13 indicates that a one percent increase in the GDP of the importing country results in a 0.13 percent increase in total intra-COMESA trade holding other factors constant. Similarly, the GDP coefficient of 0.78 implies that a one percent increase in GDP of the exporting country increases total intra-COMESA trade by 0.78 percent holding everything else constant. These results imply that improvement in the economic performance of COMESA Member States increases intra-COMESA trade. The results are in line with the conclusion reached in the literature that larger nations tend to trade more (Helpman and Krugman 1985; Hassan, 2019; Ebaidalla and Mohammed, 2023).

Similarly, the results show that the coefficient of the population of the exporting country is positive and significant at a 1 percent level of significance. The coefficient of 0.15 implies that a one percent increase in population of the exporting country increases the total intra-COMESA trade by 0.15 percent. The findings suggest that increase in population of exporting country, increases labour which then increases productivity and thus, increase in exports which encourages intra-COMESA trade. In addition, this finding is in line with the studies by Kien (2009) and Ebaidalla and Mohammed (2023) who argued that populated countries often leverage economies of scale to expand their trading activities especially with neighbouring trading partners, consequently increasing intra-regional trade.

Table 5: Stochastic frontier gravity model results

Variables	**Dep. Variable: Total Intra-COMESA trade**	
	(1)	(2)
Ln GDP (importing country)	0.131***	0.129***
	(0.043)	(0.042)
Ln GDP (exporting country)	0.757***	0.781***
	(0.040)	(0.041)
Ln Bilateral distance	-0.181***	-0.251***
	(0.063)	(0.076)
Ln Land area (importing country)	-0.043	-0.016
	(0.030)	(0.033)
Ln Population (importing country)	-0.026	-0.049
	(0.047)	(0.048)
Ln Population (exporting country)	0.155***	0.150***
	(0.024)	(0.026)
Ln FDI (exporting country)	0.329***	0.328***
	(0.037)	(0.037)

Shared border		-0.267**
		(0.135)
Common language		0.155*
		(0.087)
Constant	-0.980	-0.898
	(1.007)	(1.001)
Observations	5224	5224
Number of Id	240	240
Wald statistic	1184.5***	1319.03***
Lambda	14.052***	14.689***
Sigma v	0.537***	0.557***
Sigma μ	7.551***	8.181***

Robust standard errors in parentheses

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

However, unlike Brada and Méndez (1985) and Deluna and Cruz (2013) who found that the land area and population of the importing country positively impact intra-regional trade, this study finds the coefficients of the land area and population of the importing country to be insignificant meaning they are not significant factors in explaining the changes in intra-COMESA trade.

The coefficient of the FDI of the exporting country is positive and significant at a 1 percent level of significance. The FDI coefficient of 0.33 indicates that a 1 percent increase in foreign investment in the exporting countries increases intra-COMESA trade by 0.33 percent holding other factors constant. These results imply that FDI in exporting countries boosts intra-COMESA trade. This can be attributed to the practice of many multinational enterprises capitalizing on the affordable labour and manufactured goods available in host countries for export to their home country markets. As a result, this leads to an increase in export flows and consequently, an increase in intra-COMESA trade.

It is notable that the coefficients of the GDP variables, FDI and the population of the importing country remain broadly the same with the inclusion of "beyond border" variables in column 2.

The study also finds that the coefficient of the bilateral distance between trading partners to be negative and significant at a 1 percent level of significance. The study notes that the coefficient of bilateral distance between trading partners becomes more negative (reduces from -0.18 to -0.25) after the inclusion of "beyond borders" variables which were previously excluded in the model 1. The change could be attributed to the correlation between bilateral distance, shared borders and common language which biases the coefficients. This reflects the importance of "beyond border" variables in explaining changes in intra-COMESA trade. The bilateral trade coefficient of 0.25 implies that a 1 percent increase in the distance between trading partners reduces intra-COMESA trade by 0.25 percent, holding other factors constant. A larger distance is highly correlated with large transport costs and other costs of trade like communication costs, transaction costs, among others. Thus, the results support the theory that higher distances result in higher costs which, consequently, discourages trade between the trading partners. The results are also supported by Fan and Huang (2017) and Peng et al. (2020).

Regarding the "beyond border" variables, the results presented in Table 5 indicate that the coefficient of common border is negative and significant at a 5 percent level of significance. The common border coefficient of -0.27 implies that, sharing a common border among trading partners reduces intra-COMESA trade by 0.27 percent, on average, compared to those without a common border ***ceteres paribus***. This implies that a common border among trading partners discourages trade compared to trading partners that do not share a common border. This can be explained by the fact that most trading partners that share a common border have the same comparative advantage because of skills and knowledge spillovers and that they are exposed to similar geographical and environmental factors. As a result, they end up producing similar goods and services which discourages trade among them even when the cost of transaction is low.

Lastly, the results indicate that the coefficient of common language is positive and significant at a 10 percent level of significance. The coefficient of common language of 0.16 indicates that sharing a common language among trading partners increases intra-COMESA trade by 0.16 percent, on average, compared to those without a common language, holding everything else constant. These results imply that sharing a common language among trading partners makes communication easier, which encourages trade between them and consequently increases intra-COMESA trade. Common language reduces language barrier which could deter trade agreements and negotiations among trade partners. This finding is in line with Deluna and Cruz (2013) who argued that commonality of language promotes trade as it is associated with cultural differences.

A notable finding of the frontier analysis is that both the sigma (u) and lambda coefficients are positive and statistically significant implying presence of inefficiency in the model and validating the use of a stochastic frontier gravity model. Indeed, dividing the variance of u by total variance gives 0.99, implying 99 percent of the disturbance term results from inefficiency.[21]

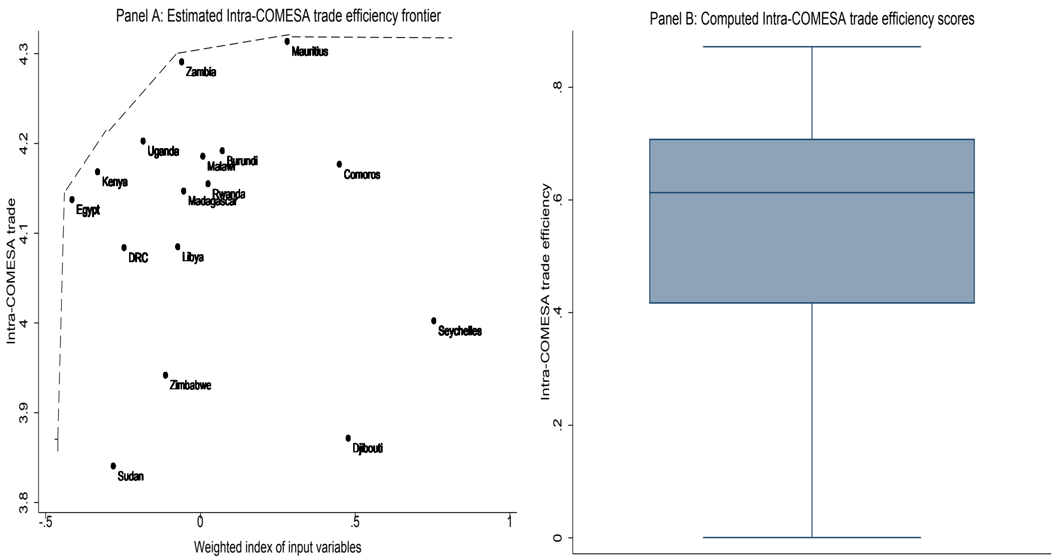
In summary, the study finds that an increase in the GDP of exporting and importing countries, increase in the population and FDI of the exporting country and presence of common language among trading partners boosts intra-COMESA trade. On the other hand, the study finds that a larger distance between trading partners and having a common border discourages trade which further reduces intra-COMESA trade.

Panel A of Figure 3 illustrates trade capacity. SFA computes the frontier (dotted line) as the maximum attainable total trade which is subject to countries' fundamental factors influencing trade capacity.[22] The gap between an observed input-output combination and the frontier measures each country's trade efficiency. The figure shows that COMESA Member States have room for improvement in intra-trade, as most are below the trade frontier i.e., their inter-Member State trading is less than potential. Panel B in Figure 3 shows the ranges of intra-COMESA trade efficiency scores calculated by the SFA method. The figure points towards a less dispersed intra-COMESA trade efficiency scores, with seventy-five percent of the scores falling below 0.7 and twenty-five percent below 0.4.

21 This is obtained by taking $(\text{sigma } \mu)^2/((\text{sigma } \mu)^2+(\text{sigma } v)^2)$

22 For clarity, we consolidate the primary factors influencing tax as outlined in section 3.1 (including GDP, bilateral distance, population, land area, and FDI) into a single index representing intra-COMESA trade potential. We standardize all variables so higher values indicate better conditions, inversing those with a negative relationship with revenue, like bilateral distance.

Figure 3: Intra-COMESA trade efficiency

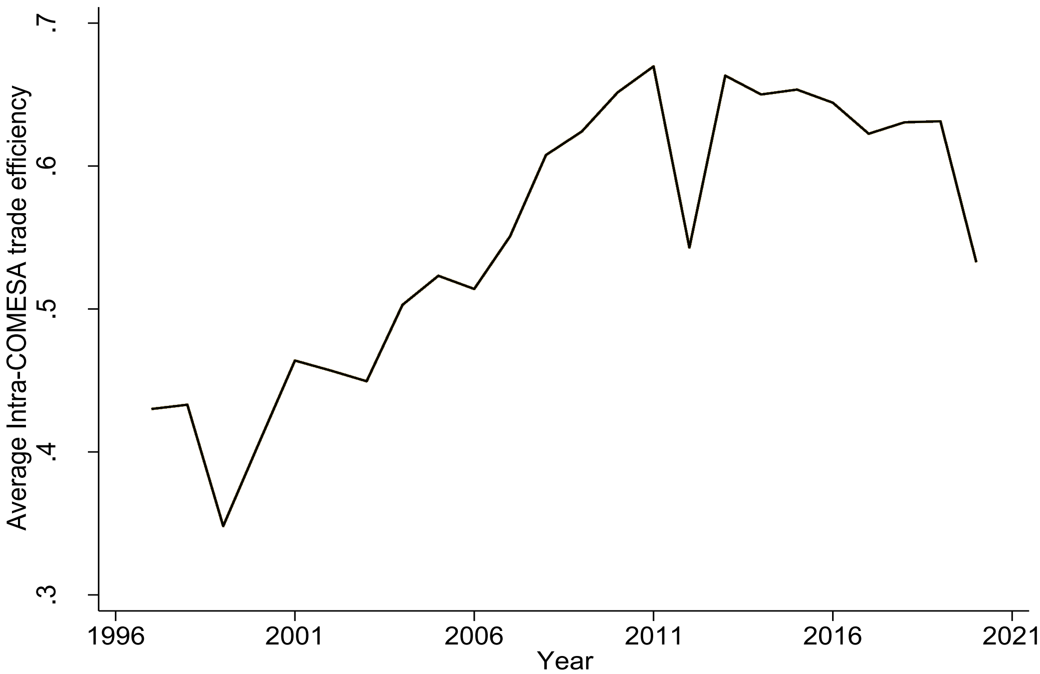


***Source**: Authors' analysis based on the data sources described in section 3.3.*

Figure 4 further shows the trend of intra-COMESA's average trade efficiency from 1997 to 2020. Trade efficiencies are estimated to range from 0 to 1, with 1 indicating maximum trade potential is met. In general, the results imply that intra-COMESA trade efficiency improved substantially from 1997 to 2020. Albeit unpredictable, the curve indicates an increase in the average intra-trade efficiency[23] from 0.42 in 1997 to slightly over 0.60 in 2020.

23 Intra-trade efficiency ranges from zero '0' to one '1' where 0 indicates low intra-trade efficiency and 1 indicates high (full) intra-trade efficiency.

Figure 4. Average intra-COMESA trade efficiency, 1997–2020.



Source: *Authors' calculations*

4.5 Intra-COMESA Trade Efficiency and FTA

The intra-trade efficiency scores computed in section 4.4 are employed as the dependent variable in a regression framework (based on equation 6) using fixed effects estimation, and the results are presented in Table 6. The first two models (columns 1 and 2) include FTA dummy that takes the value of 1 in the period after the implementation of FTA, columns 3 and 4 consider trade freedom as the proxy for FTA implementation while columns 5 and 6 re-estimate models 2 and 4 using Fixed Effects with Driscoll-Kraay standard errors which correct for biases resulting from heteroscedasticity, serial correlation, and cross-sectional dependence. Other variables included are WTO participation to account for the influence of international engagement/commitment undertaken by COMESA Member States, fragility index to capture political stability and components of economic freedom related to investment and international trade policies such as investment and financial freedom that may elucidate variations in trade flow.

As evidenced in Column 1, 2 and 5, the coefficient of COMESA FTA dummy is positive and significant at a 1 percent level of significance. The 0.2 coefficient indicates that the implementation of the COMESA FTA (2001 onwards) increased intra-regional trade efficiency by 0.2 points, holding everything else constant. This implies that implementation of COMESA FTA has had a positive effect on intra-COMESA trade efficiency. In other words, there were increased imports and exports between COMESA Member States, reducing trade with non-COMESA member countries. This implies that the increase in intra-COMESA trade efficiency discussed in section 4.4 was majorly attributed to implementation of COMESA FTA. In fact, intra-trade efficiency averaged 0.40 in the period 1997-2000, and this increased to an average of 0.45 in the subsequent 5-year period (2001-2005) after the COMESA FTA implementation, and further to an average of 0.60 in the period 2006-2010. Furthermore, despite the global crises of 2011 and 2020, intra-COMESA trade efficiency remained relatively higher than previous years, averaging 0.63 over the period 2011 to 2020.

Table 6: Explaining trade efficiency

	Dep. Variable: Intra-COMESA trade efficiency					
					FE - Driscoll-Kraay SE	
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
FTA	0.201***	0.197***			0.197***	
	(0.011)	(0.011)			(0.030)	
Trade freedom			0.087***	0.085***		0.085**
			(0.012)	(0.012)		(0.036)
Investment freedom	-0.011***	-0.010***	-0.017***	-0.016***	-0.010	-0.016
	(0.002)	(0.003)	(0.002)	(0.002)	(0.011)	(0.011)
Financial freedom	0.034***	0.028**	0.019**	0.012	0.028	0.012
	(0.012)	(0.012)	(0.007)	(0.008)	(0.022)	(0.030)
Fragility index		0.025***		0.057***	-0.025	0.057*
		(0.007)		(0.013)	(0.019)	(0.029)
WTO	0.037***		0.035***			
	(0.003)		(0.010)			
Constant	0.290***	0.411***	0.241***	0.383***	0.411***	0.383**
	(0.045)	(0.055)	(0.046)	(0.0666)	(0.111)	(0.180)
Observations	4,381	3,785	4,366	3,770	3,785	3,770
ID	240	225	240	225	225	225
R-squared	0.263	0.296	0.080	0.109	0.296	0.109
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1						

The results further show that active involvement in international trade negotiations such as those conducted within the WTO, plays a significant role in reducing the trade gap between trading partners. This, in turn, enhances trade efficiency within the COMESA region. In other words, when COMESA Member States joined the WTO, their efficiency in trading activities increased by 0.1 units. Other variables that are found to impact intra-COMESA trade efficiency include investment freedom (negatively) and financial freedom and political stability (positively). For every unit increase in financial freedom and political stability scores, intra-COMESA trade efficiency increased by 0.03 units.

In columns 3 and 4, the study employed trade freedom index rather than the FTA dummy. Trade freedom index measures the absence of tariffs and non-tariff barriers that affect trade. The estimated coefficient of trade freedom index is about 0.08, statistically significant at 1 percent level, clearly indicating that reduced tariffs and non-tariffs by Member States act as a key force driving improvement of intra-COMESA trade efficiency.

In columns 5 and 6, this study employed the fixed effects estimation with Driscoll-Kraay standard errors which correct for biases resulting from heteroscedasticity, serial correlation, and cross-sectional dependence, which have all been detected in the model. The coefficients of FTA dummy and trade freedom index remain positive and statistically significant, indicating FTAs enhance intra-COMESA trade efficiency.

Results revealed that the COMESA free trade agreement increases the technical efficiency of the region's export flows to trading partners. This implies a positive impact of COMESA's Member States' involvement in intra-regional trade in narrowing the trade gap with external trading partners. The results also show that exports efficiency improves with higher trade freedom and financial freedom and better state capacity to handle conflicts when they arise.

5 Conclusion and Policy Implication

The main objective of the study was to assess the evolution of intra-COMESA trade efficiency levels, investigate the extent to which COMESA's FTA has contributed to intra-COMESA trade efficiency and identify some of the key constraints and challenges hindering intra-COMESA trade. The study employed the stochastic frontier gravity model to estimate the intra-COMESA trade efficiency. Subsequently, the Fixed effects method was employed to assess the extent to which COMESA FTA influences the trade efficiency scores estimated in the frontier model.

The study found that intra-COMESA trade performance is influenced by various factors including the incomes of both the importing and exporting country, foreign direct investment, the population of the exporting country, the distance between them and other elements such as a common border and a common language. Intra-COMESA merchandise trade is driven by increased income within COMESA Member States, higher FDI, common language and a higher population of the exporting country. However, larger distances between trading partners discourages intra-COMESA trade due to high transport costs. Therefore, to encourage intra-COMESA trade Member States can consider (i) strengthening trade linkages and /partnerships with neighbouring countries that have rapidly growing populations and expanding markets, as well as higher incomes (ii) promoting the learning of nearby countries' languages e.g., English in French speaking countries or Swahili in the Eastern African region to lower the costs of communication, reduce language barrier that can deter trade agreements and negotiations and consequently favour more trade.

The study also found that, on the one hand, intra-COMESA merchandise trade is below its potential with intra-trade efficiency averaging 0.56 over the study period. This implies that there is room for COMESA Member States to trade more with each other. On the other hand, the study found that COMESA FTA has contributed to improvement in the intra-COMESA merchandise trade efficiency.

Although the average efficiency level has been fluctuating, the overall trend has been positive. Intra-trade efficiency averaged 0.40 in the period 1997-2000, and this increased to an average of 0.45 in the subsequent 5-year period (2001-2005) after the COMESA FTA implementation, and further to an average of about 0.60 in the period 2011 to 2020. This underscores the role of COMESA FTA in improving trade efficiency. Therefore, to improve intra-COMESA trade efficiency, the COMESA Secretariat can consider (i) encouraging non-participating COMESA Member States such as Ethiopia, Eritrea, Democratic Republic of Congo, and Somalia to join the COMESA FTA given its role in enhancing intra-trade efficiency (ii) enhancing seamless flow of goods in the COMESA FTA through efforts to reduce non-tariff barriers to trade and increased trade facilitation to enhance intra-COMESA trade efficiency.

Lastly, the study found that active involvement in trade negotiations like WTO, political stability and "beyond the border" indicators such as trade freedom and financial freedom promotes intra-COMESA trade efficiency. Investment freedom on the other hand was found to have a negative effect on intra-COMESA trade efficiency. Thus, to improve the intra-COMESA trade efficiency it is important that COMESA actively promotes intra-regional trade to narrow the gap with external trading partners as well as engage to improve "beyond the border" indicators such as trade and financial freedom. The Member States can also consider promoting financial deepening and broadening by increasing provision of financial services through wider choices of financial services and better access for different socioeconomic groups which enhances credit access and liquidity thereby favouring more trade.

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The Effects of Air Transport Service on Trade of Pharmaceutical Goods in COMESA

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Abstract

Air transport service and pharmaceutical trade nexus are seldom discussed at international and national forums and policy dialogues, yet they are inextricably linked to each other. The social service function of air transport linked to international tourism is widespread in literature relative to the economic service function of air transport related to trade and business tours. Air transport services are vital in the COMESA region especially during periods of natural disasters such as the COVID-19 pandemic period. COMESA is prone to several manmade and natural disasters that curtail the growth and development of the region. Growing intra-pharmaceutical trade in COMESA, which is currently below 5 percent, is one way to cushion the region from the negative economic and social effects of these calamities. It is believed that improving air transport services would stimulate intra-trade of pharmaceutical goods. This study investigates the effects of air transport service on trade of pharmaceutical goods in COMESA. Specifically, the study analyzes the state of air infrastructure quality in the region and estimates the effects of air transport services on intra-COMESA pharmaceutical trade. Using the gravity model, the PPML estimator and the 2021 annual pharmaceutical trade data for 19 COMESA Member States, the study found out that air transport service positively affects intra-COMESA pharmaceutical trade. A 1 unit increase in air connectivity by COMESA exporting and importing countries would stimulate intra-COMESA pharmaceutical trade by 6.5 and 6 units respectively. This implies that a 1 unit increase in air connectivity by all COMESA Member States would induce intra-COMESA trade in pharmaceuticals by 12.5 units. Results further indicate that the quality of air infrastructure in COMESA is 0.45 scores below the global average score of 4.55. The study recommends COMESA Member States to consider increasing their city-to-city air transport connectivity in order to increase intra-COMESA trade in pharmaceuticals. This can be achieved through investments in projects aimed at increasing the availability and quality of air infrastructure such as fleets of aircraft and airports across COMESA Member States.

Key Words: *COMESA; Air Transport service, Pharmaceutical Trade, A*ir connectivity, COMESA

1. Introduction

Air transport service is key to the COMESA region. It is closely linked to international trade and therefore dovetails with one of the region's main objectives of boosting intra-COMESA trade (COMESA, 2018). The biggest advantage of air transport over other means is that of speedy and limitless service (Pinto & Abayadeera, 2015). Air transport can service distant, and geographically disadvantaged remote areas. Although it sometimes relies on other modes such as road and rail for services to and from the airport, air transport services can speedily access anywhere on earth making it suitable for delivery of emergency supplies such as pharmaceutical goods.

Like any other regions of the world, COMESA was not spared by the recent global pandemic. The first case in COMESA was recorded in Egypt on 14 February 2020 (Chikabwi, 2022). The region was gravely affected by the virus and Member States suffered severe economic disruptions affecting production and supply of COVID-19 supplies meant to curtail further spreading of the virus (Ronoh, 2022). Production was adversely affected by strict government lockdowns which disrupted the global supply of inputs such as active pharmaceutical ingredients. Though the pharmaceutical industry was exempted from lockdown restrictions, COMESA pharmaceutical trade suffered downstream and upstream spillover effects of the lockdowns (Strong et al., 2020).

According to the COMSTAT data, intra-COMESA pharmaceutical trade declined by 21.2 percent in 2020 from $352 million in 2019 before rising to $375 million in 2021. COMESA non-pharmaceutical goods, not surprising, took the same pattern, traded less in 2020 than in 2019 and 2021 (COMSTAT data hub). Most of the goods in this category were classified as non-essential services and were regulated by regional and national COVID-19 lockdown regulations. Accordingly, there was a drop in non-pharmaceutical trade. COMESA Member States were instead expected to trade more pharmaceutical goods within the region during these needy times. It is well acknowledged that trade of emergency health related goods highly depends on the efficiency of air transport services (Bao et al., 2021). Thus, air transport services played a key role in the COMESA region during this critical time. The severity of the virus requires speedy movement of life-saving pharmaceutical goods to reduce loss of lives and combat further spread. The ability of COMESA to contain the virus was dependent on the region's proficiency in trading pharmaceutical goods within itself among other factors.

In addition, COMESA region is prone to several natural and manmade disasters and shocks that require quick mitigatory measures as they threaten the equilibrium of economic, social, and ecological systems. The region is susceptible to drought, floods, cyclones, and natural diseases such as Malaria, Cholera, Tsetse, Ebola and COVID-19 (COMESA COVID-19 Situational Update, 2020; Chibomba, 2022). Natural and manmade disasters curtail regional growth and wellbeing if not timely and properly managed. They lead to human, animal, and environmental loss of life. The earlier they can be mitigated, the better.

Air transport service is ideal in the delivery of emergency supplies during disasters (Wilson, 2018). It shortens delivery time and easily reaches remote areas. Air transport therefore is key in promoting intra-COMESA pharmaceutical trade, which is currently low. Low intra-COMESA trade puts the region at high risk as it must rely on external supplies which are outside COMESA's control. This study examines the effects of air transport service on intra-COMESA pharmaceutical trade.

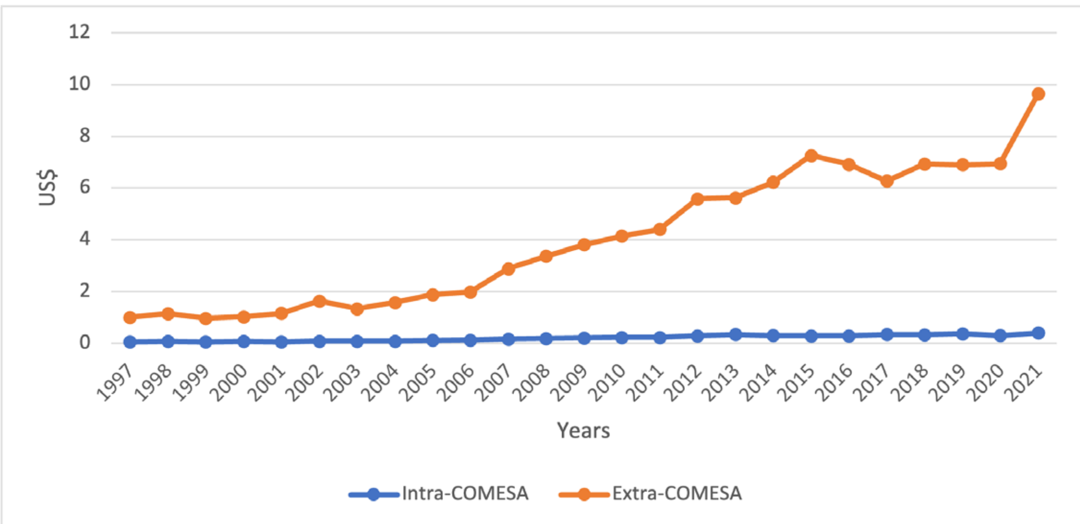
This paper is organized in five sections. Following this introductory section is a review of literature on the role of transport services on pharmaceutical trade. Section 3 highlights the empirical strategy. Section 4 presents and discusses the findings and section 5 concludes the study.

1.1 Intra-Trade of Pharmaceutical Goods in the COMESA Region

Intra-COMESA trade in pharmaceutical goods remains subdued despite regular fluctuations in demand induced by periodic natural disasters (Ronoh, 2022). Despite insatiable demand for pharmaceuticals from other Member States during COVID-19, COMESA countries continued trading with non-COMESA Member States. Thus, trading with non-COMESA countries was not market-seeking driven.

Pharmaceutical trade among COMESA Member States with one another is low[25] because they prefer trading with non-COMESA Member States. According to the COMSTAT data, in 2021 when COVID-19 was at its peak, COMESA Member States traded less than 4 percent of total tradable pharmaceutical goods within the region. Above 96 percent of the pharmaceutical goods were traded with non-COMESA Member States. The region exports and imports more pharmaceutical goods to and from the Rest of the World (RoW) than within the region (Ronoh, 2022). This is not an ideal situation especially during periods of natural disasters such as pandemics where homegrown remedies are more preferred than foreign. Figure 1 shows intra-and-extra pharmaceutical trade in the COMESA region.

Figure 1: Intra-and extra-COMESA pharmaceutical trade (1997 to 2021)

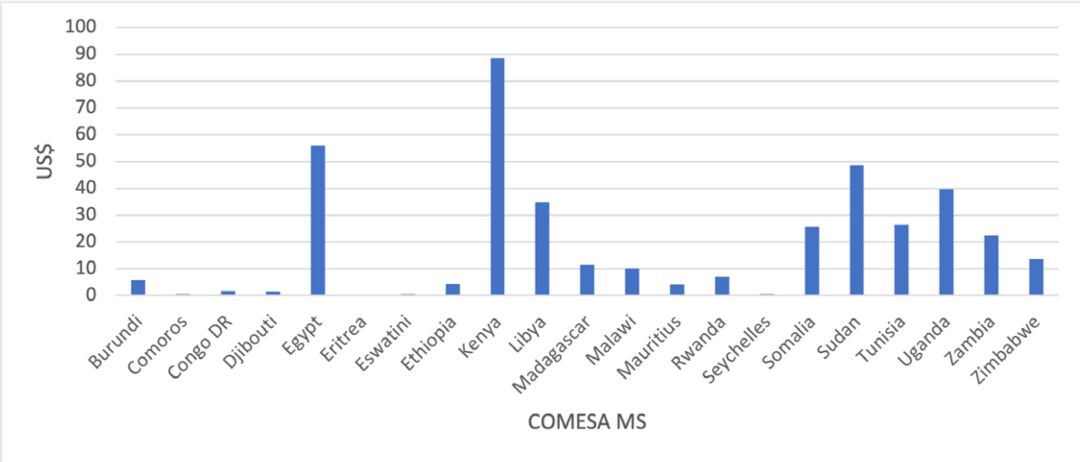


Source: *COMSTAT Database*

Figure 1 shows increasing trends for both COMESA intra-and-extra trade between 1997 and 2021. Whereas extra-COMESA trade increased by 858 percent, intra-COMESA exports grew by less than 664 percent. This implies that trade between 1997 and 2021, pharmaceutical trade was largely externalized than internalized. Even in 2021 at the peak of COVID-19 when COMESA was in dire need of pharmaceutical goods for regional use, more was externalized than internalized. COMESA internal trade in pharmaceutical goods is dominated by a few countries as shown in Figure 2.

25 COMSTAT data

Figure 2: Intra-COMESA pharmaceutical trade-country level analysis for the year 2021



Source: *COMSTAT Database*

Figure 2 depicts intra-COMESA pharmaceutical trade country statistics. The graph shows that COMESA intra-pharmaceutical trade is dominated by Kenya, Egypt, Sudan, Uganda and Libya. Intra-COMESA contributions by other countries such as Comoros, Eritrea, Eswatini, and Seychelles are quite negligible. Whereas Kenya traded close to US$ 90 million worth of pharmaceutical goods within the COMESA region, Comoros, Eritrea, Eswatini, and Seychelles traded less than US$ 1 million. Intra-COMESA pharmaceutical trade disparity across COMESA Member States may be because of poor air transport infrastructure quality. Air transport infrastructure quality in the COMESA region is generally low.

1.2 Air Transport Infrastructure Quality and Intra-Pharmaceutical Trade in the COMESA Region

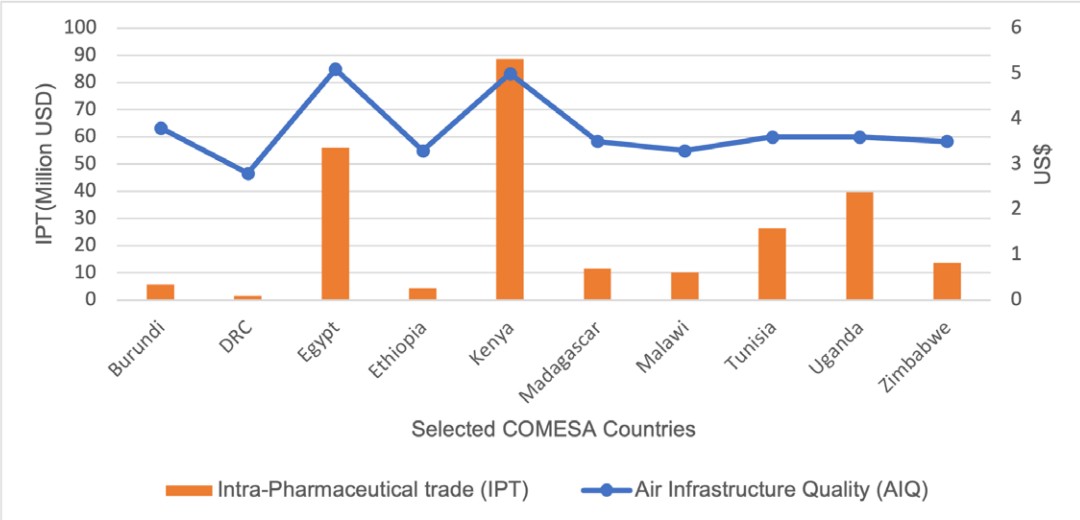
Poor infrastructure quality is viewed as one of the biggest obstacles in promoting trade in developing economies (Sénquiz-Díaz, 2021; Stanley, 2020). According to Principal (2009), low levels of internal and external trade in Africa is linked to deficiences in trade infrstructure. Mbekeani (2007) argued that infrastructure development is key in determining a country's ability to produce and move goods to potential market destinations. As noted by Chinzara et al., (2023) and Hannafi et al., (2022) weak infrastructure impedes Africa's participation in international trade, particularly land-locked and small island African countries. COMESA which constitutes half of the total landlocked African countries[26] is thought to be at a greater trade disadvantage than other African regional economic communities (RECs).

Low quality air transport infrastructure development is a big hurdle for COMESA to reap potential trade gains. Of the 14 COMESA Member States ranked on the air transport infrastucture global rank, only four[27] scored above the global average of 4.55 scores. Close to 60 percent of the COMESA Member States scored below the region's average of 4 scores. Only Egypt, Kenya, Mauritius, Rwanda, Seychelles and Zambia scored above half the regional average scores. A cross analysis of air infrastructure quality and intra-COMESA pharmaceutical trade shows that countries with better air

26 Burundi; Eswatini; Ethiopia; Malawi, Rwanda; Uganda Zambia; Zimbabwe
27 Egypt, Kenya, Mauritius, and Rwanda

infrastructure quality trade more within the region (see Figure 3).

Figure 3: Air Infrastructure quality and intra-pharmaceutical trade in selected COMESA countries



Source: *World Economic Forum (WEF), ITC Trade Map and COMSTAT Database*

Figure 3 shows the relationship between air infrastructure quality and intra-pharmaceutical trade in the COMESA region. The data shows that countries with good air infrastructure quality trade more within the region. Egypt and Kenya are top two COMESA Member States in the provision of quality air infrastructure in the region. The same countries also trade more pharmaceutical goods in the region. Countries with poor air infrastructure quality such as DR Congo and Ethiopia also trade less within the region.

Besides the importance of quality of air infrastructure in trade, availability of appropriate infrastructure is also equally important. Air transport infrastructure characterised by non-existent air flights across most Member States and limited air cargo flights to Member States continue to be a challenge in COMESA (COMESA, 2021). In the 21 COMESA countries[28] , there is only 137 international airports and 726 aircrafts compared to 658 international airports and 5233 aircrafts for the EU[29]. International airports do not just serve host countries. They link COMESA Member States with one onother and the outside world. Of the 21 COMESA countries, four have only one airport, six have only two, and five have above 10 international airports. Whilst other COMESA Member States like Kenya have 173 aircrafts, Burundi and Eritrea have zero each. The evidence reveals that there are outstanding disparities in air transport facilities/services across COMESA Member States and this is likely to continue to impede trade in the region.

Quality and availability of air infrastructure greatly facilitate air transport networks between countries. Countries without proper, adequate and affordable air transport infrastructure may find it difficulcult to participate in regional and global activities that require efficient air transport services. By bridging physical distance between countries, air transport infrastructure facilitates country-to-country air connectivity for ease of movement of passangers, goods and services. Air connectivity

28 Burundi; Comoros; DRC; Djibouti; Egypt; Eritrea; Eswatini; Ethiopia; Kenya; Libya; Madagascar; Malawi; Mauritius; Rwanda; Seychelles; Somalia; Sudan; Tunisia; Uganda; Zambia and Zimbabwe

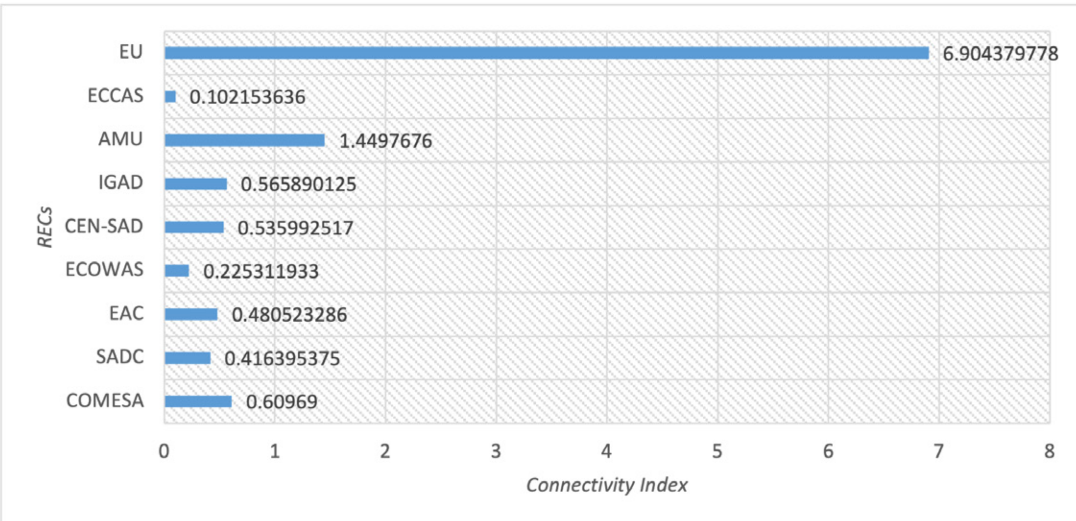
29 Respective REC websites, flightradar and planespottersnet.

refers to the extent to which a country's cities are connected to other cities around the world. It measures the density of connectivity across cities in the world. The International Air Transport Association 2019 report opined that better air connectivity increases trade. The report indicates that increasing air connectivity by 1 percent induces trade by 6 percent (International Air Transport Association, 2019).

1.3 Status of Air Connectivity in the COMESA Region

In terms of air connectivity, COMESA region is highly connected when compared with other regions in Africa. This means that cities of COMESA Member States are well connected to one another making it easier and efficient to move goods from one state to another. The region is ranked number two after the Arab Maghreb Union. Economic Community of Central African States (ECCAS) is the least connected region in Africa. However, when ranked with other regions outside Africa, the European Union for instance, COMESA appears to be lowly connected than reflected within the African context (International Air Transport Association, 2019). COMESA's rank relative to other African regions does not imply the region is doing well but means it is performing better among the poorly performing regions. Figure 4 compares air connectivity by region.

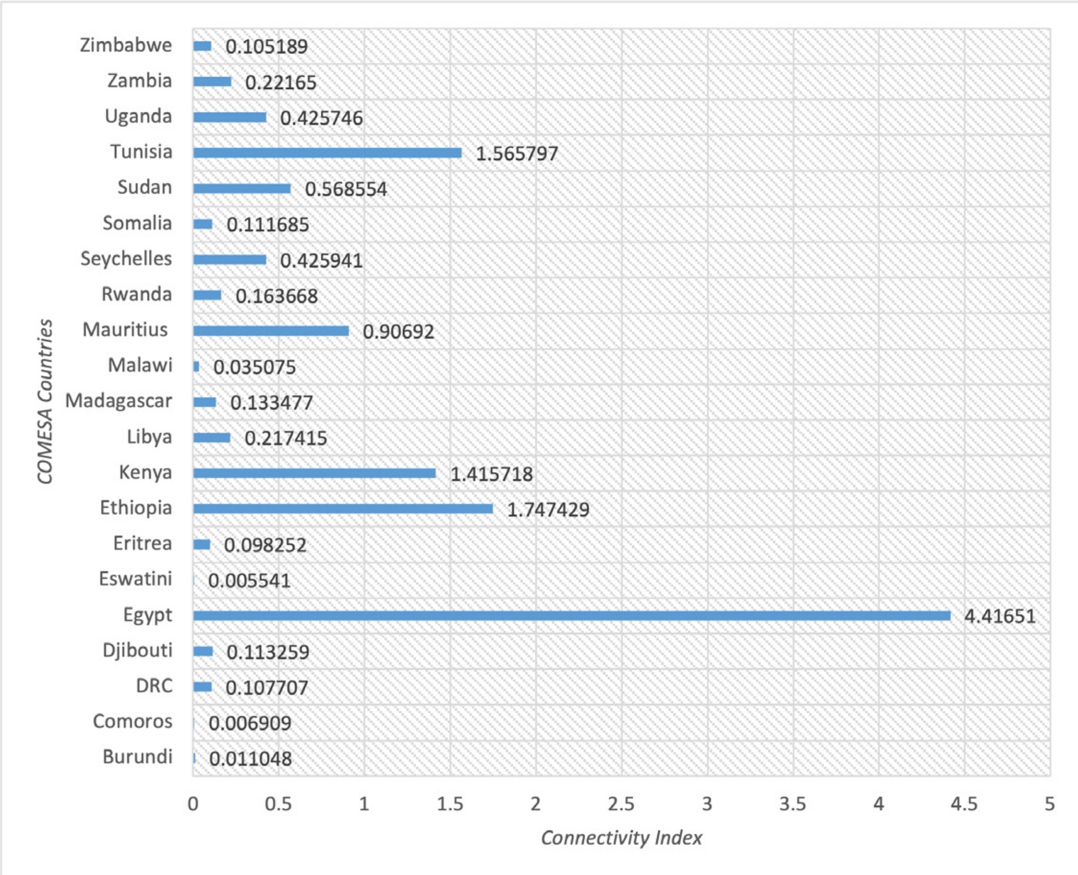
Figure 4: Average air connectivity by region



Source: *IATA 2019 Report*

Figure 5 shows that Egypt is the most connected country not only in the COMESA region but in Africa. This means that cities in Egypt are more connected to other cities in the COMESA region and other cities around the world. Figure 5 shows the level of air connectivity across all COMESA countries.

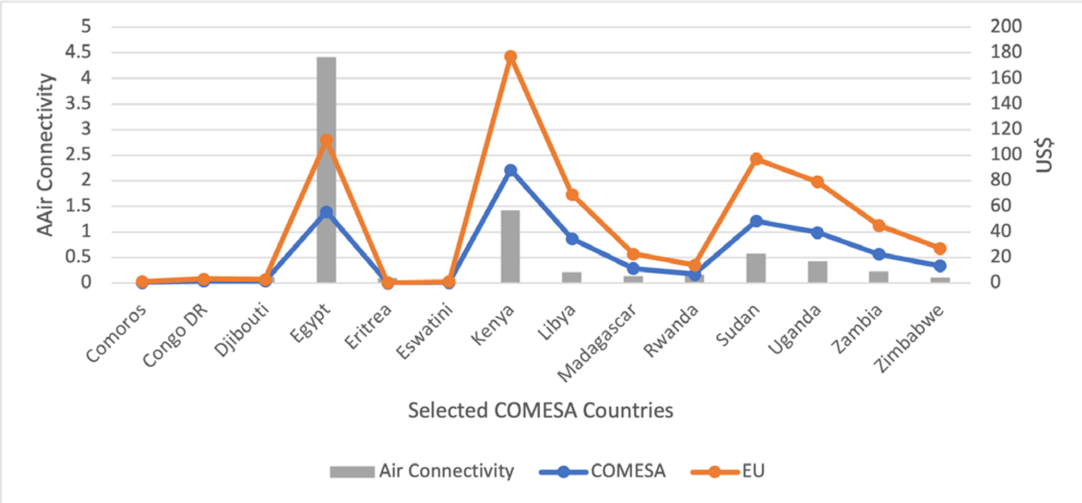
Figure 5: Air connectivity across COMESA Member States



Source: *IATA 2019 Report*

The above figure indicates that Eswatini, with a connectivity index of 0.006, is the least connected country in the COMESA region followed by Comoros, Burundi, and Malawi. Ethiopia on the other hand is the second most connected COMESA country followed by Tunisia, Kenya, Mauritius, and Sudan. Literature suggests that highly connected countries trade more than poorly connected (International Air Transport Association, 2019). This implies that Egypt, Ethiopia, Tunisia, Kenya, Mauritius, Sudan, Uganda, Seychelles, Zambia, and Libya should be trading more relative to other less connected Member States such as Eswatini, Comoros, Burundi, and Malawi. Figure 6 shows the nexus between air connectivity, intra-COMESA and extra-EU pharmaceutical trade.

Figure 6: Nexus between air connectivity, intra-COMESA and extra-EU pharmaceutical trade



***Source:** COMSTAT Database and IATA 2019*

Figure 6 shows the relationship between air connectivity and pharmaceutical trade within COMESA and the EU region. The graph suggests a positive relationship between air connectivity and COMESA and EU pharmaceutical trade, implying that better connectivity stimulates both intra and extra-trade. It further indicates that countries with better connectivity, Egypt, Kenya, Sudan and Uganda for instance, trade more within the COMESA region and with the EU. In contrast, the graph indicates that countries which are lowly connected such as Eswatini, Eritrea, Comoros, DR Congo and Djibouti, trade less within the COMESA region and with the EU as well. The analysis suggest that air connectivity influences pharmaceutical trade. This study, therefore, seeks to investigate the effects of air transport service on intra-COMESA pharmaceutical trade.

1.4 Problem Statement

Notwithstanding the high susceptibility of the COMESA region to natural and manmade disasters, intra-trade in pharmaceutical goods remains low in COMESA relative to trade with the outside world. Low level of intra-pharmaceutical trade in COMESA is linked to poor air transport services in the region. Air transport markets in the COMESA region are poorly connected and partially liberalised. Cities within the COMESA region are poorly connected to one another. Only eight out of 21 COMESA Member States have ratified the Single African Air Transport Market[30] (SAATM). This implies that intra-COMESA markets are still closed which negatively affect air connectivity, air travel costs harmonisation and pharmaceutical trade. Low intra-trade in pharmaceuticals puts COMESA at high risk especially during pandemics as the region has to rely on supplies from other regions. For instance, in 2021 at the peak of COVID-19, 95 percent of pharmaceutical goods were outsourced (ITC Trade map). This implies that COMESA Member States rarely trade with one onother. Should this undesirable trade pattern continue, COMESA would be greatly exposed to global trade shocks. Thus, mitigating natural disasters which demands urgent actions to save lives would be difficult. It is believed that improving air transport services would stimulate intra-COMESA pharmaceutical trade.

30 https://www.comesa.int/eight-comesa-countries-have-signed-the-air-transport-market-agreement/

The study sets to investigate the effects of air transport service on intra-COMESA pharmaceutical trade. Specifically, the study seeks to analyse the state of air infrastructure quality in the COMESA region and quantify the effects that air transport service have on intra-COMESA pharmaceutical trade. In order to meet the proposed study objectives, the study sought to provide answers to pertinent questions pertaining to the current state of air infrastructure quality, air connectivity and the effects that transport services have on intra-pharmaceutical trade in the COMESA region.

Notwithstanding the important role of air transport services in national and regional growth and development, the socio-economic transformation part of air transport services is less understood compared to other transport mode, road, rail and sea for instance.The role of air transport services in trade in general and trade of emergency goods in particular, has received little research attention. Literature on this area, from developing countries perspective is therefore largely missing. This study seeks to investigate the effects of air transport service on trade of pharmaceutical goods in the COMESA region.

2. Literature Review

2.1 Theoretical Literature Review

The classical Ricardian trade theory is one of the old models which is still highly relavent in today's trade (Ricardo, 1817). The theory is based on the comparative advantages of nations in the production of goods. However, in real world, services are traded too, and countries may have comparative advantage in provision of certain services than others. Those countries should therefore focus on provision of such services and trade them to other countries.

This study considers air transport service in the Ricardian framework. The conventional theory is based on 2-country and 1 factor assumptions and links trade to technological differences between countries. The model considers simple technologies used to produce good x in country i and country j using constant unit input of $a(x)$ and $a^*(x)$ respectively. This implies that:

$$\frac{a(x)}{a^*(x)} < \frac{a(x')}{a^*(x')}, \text{ for } x' > x \quad (1)$$

Given that the technologies for both countries are symetrical, then the following condition should be met:

$$a(x) = a^*(1-x), \quad (2)$$

This implies that $a(x)$ is non-decreasing and $a^*(x)$ non-increasing in x. In the absence of transportation costs, country i's production satisfy the following condition:

$$a(x) < a^*(x) \quad (3)$$

However, in the real world, tradable goods and services incur transport service costs which are inversely related to transport infrastructure development. Such costs are more significant in international trade than domestic trade and sometimes in landlocked countries than non-landlocked.

The transportation service cost gap in the Ricardian theory was addressed by Dornbusch et al. (1977) model who extended the basic model by introducing transportion costs.

2.2 Transport Service Cost and the International Goods Transfer Framework: The Iceberg Theory

The iceberg theory which was propounded by Paul Samuelson in 1954 and first applied in international economics by Krugman (1991), is the bedrock of modern trade and economic geography. Modelled in shipping costs logic, (Samuelson, 1954) put forward that like an iceberg which melts when transported, product price is bound to change, subject to transport service costs, on their way to the final destination. These costs are however, substantive when it comes to international trade. Samuelson's concept states that, of the total amount of the starting iceberg transported, only a fraction arrives at the destination. More of the ice melts as distance increases.

The same idea can be expressed in terms of a fuel tanker that uses up its diesel when transporting fuel. The amount of diesel that reaches the destination point is dependent on the distance travelled by the tanker.

In trade logic, the iceberg theory can be mathematically expressed in shipment terms. The theory asserts that, to deliver x goods to country j from country i , $\delta(ij^x)$ goods should have been shipped from country i, where $\delta_{ij}^x > 1$. According to the theory, not all goods reach the destination point. A constant fraction of the goods, g melts in transit. The cost of producing the melted goods is, however, equivalent to total transportation costs[31] such that per unit transport cost, T_{ij}, in the transport sector is proportional to the producer unit price, P_{ij} , in the industrial sector in country i.

Given that g, which is the same for all commodities of the quantity shipped actually arrives in country j implies that country i have to produce commodities satisfying the following condition:

$$a(x) < a^*(x)/g \qquad (4)$$

The corresponding condition for country j is:

$$a^*(x) < a(x)/g \qquad (5)$$

If equalities are imposed on both equation 4 and equation 5, no trade would take place. Trade can take place under 2 conditions. First, through inteventions that improves production efficency by reducing production costs. Second, by applying interventions that increases or the fraction of quantities actually reaches the final destination. According to Spiros et al. (1999), improving efficiency of transport services through infrastructure development is one way to increase g. Thus, improving air transport services in this regard is theoretically argued to stimulate trade.

2.3 Transport Infrastructure, Service Costs and Trade Flows

The role of infrastructure on transport service costs and ultimately trade flows was well articulated by Spiros et al. (1999). According to Spiros, good transport infrastructure improves transportation conditions and should therefore be viewed as a cost-reducing technology. Principal (2009), acknowledged the direct influence of international transport links and internal transport networks on the level of trade costs in goods markets. Thus, more efficient infrastructure stimulates trade

31 The theory assumes that the production function for the transport sector which provides transportation services to the industrial sector and the production function for industrial sector which produce the transported goods are identical.

through reduction in transport service costs facing importers and exporters. Countries engaged in trade should consider allocating their single input endowment between production of final goods and infrastructure development. This implies that comparative advantage could be on production or on distribution. Countries may have competitive production advantages but without distributional advantage.

Thus, countries seeking to increase trade should endevour to increase g through improving the quality or efficiency of transport services. This could be archieved through provision of efficient modern transport infrastructure. Since transport infrastructure development is inversely related to transportation costs, improving transport services increases g. This statement can be mathematically expressed as follows:

$$g = \frac{\theta_i \theta_j}{\tau_i \tau_j} \quad (6)$$

Where g is the fraction of quantities that actually reaches the final destination and θ_i and θ_j means transport infrastructure in country i and country j and τ_i and τ_j stand for transport costs in country i and country j respectively. Thus, by improving transport infrastructure, g, which is the fraction of quantities shipped which actually reaches its final destination, would be increased through a corresponding reduction in transportation costs. Equation 6 demonstrates that improving transport services is key in stimulating trade.

2.4 Empirical Literature Review

The trade impact of air transport services has not been extensively studied compared to other modes. Most previous studies have focused on the impacts of road, rail, and sea transport services in promoting trade, yet air transport is equally vital in servicing the globalized and inter-connected world. The air transport industry has long been perceived as a leisure-aiding service industry providing connections for social relationships in the tourism sector. Hardly has the international trade function of air transport been considered. Its trade role is less understood and highly concentrated in the developed world.

Brugnoli et al. (2018) investigated the impact of air transportation on trade flows in Italy. Using a before/after augumented gravity model and a 10 year panel dataset across 30 European countries the study estimated three different econometric specifications[32] and a Dataset Distillation (DD) model for robustness check for possible endogeneity. The study found out that air transportation postively impact trade. The findings shows that the elasticity of the impact ranges from 0.003 percent to 0.13 percent across all the different econometric specifications. Results further indicate that the effect is much stronger in high tech- and medium-tech manufacturing sectors.

Andriamananjara (2004) did a study on the link between trade and international transport services. The study applied a simple analytical model and standard graphical tools developed by the author and found out that high cost of international transport services resulting from poor transport infrastructure impedes trade. Several studies have, as a result, examined the role of transport infrastructure in improving transport services and promoting trade flows (Olarreaga 2016; Rehman, Noman & Ding 2020; Shepherd 2016; Ismail & Mahyideen 2015; Kneller & McGowan 2019).

Spiros et al., (1999) examined the role of infrastructure in influencing trade in the European Union

32 Random effect panel data, PPML, and PPML with fixed effects

(EU). The study used two different data sets[33] comprising of six[34] and nine[35] core EU countries and a gravity model augumented with additional infrastructure variables to evaluate the effects of public infrastructure on EU trade. Using the length of motorway network as a direct measure of transport infrastructure and the product of the stocks of public capital to capture differences in the level of infrastructure between EU countries, the study found the coefficients of both infrastructure variables to be positive and significant suggesting that higher level of public infrastructure facilitates trade through transport costs reduction.

A similar study was also conducted by Faheem et al. (2020) in selected South Asia countries using a diffent methodology. Unlike Spiros et al. (1999) study, Faheem et al. (2020) examined the short- and long-run impact of infrastructure on export and trade deficit during 1990–2017. Using Pooled Mean Group (PMG) estimator and cointegration techniques like Pedroni and Kao test, the study confirmed positive impact of infrastructure on exports. Results of the PMG approach confirmed existence of long-run impact of aggregate and sub-indices of infrastructure. The study established that transport, telecommunication, energy and financial sector promotes Asian exports. These findings concur with results obtained by Zheng & Hongtao (2022). Using fixed effects gravity equation and the OECD dataset (Zheng & Hongtao, 2022) found out that transportation infrastructure enhances international trade more than internal trade.

Ochieng et al. (2020) examined the relationship between transport infrastructure stock and bilateral trade flows in East Africa. The study applied a panel of 11 East African countries and bilateral export data for the period 2000 to 2018. Using disagregated infrastructure variables (disagregated into transport and Information and Communication Technology (ICT)), an infrastructure aurgumented gravity model and a Poisson Pseudo Maximum Likelihood (PPML) estimator, results confirmed positive impact of infrastructure on East African trade. In concurrance with these results, Celbis et al. (2014), using meta-analysis and meta-regression techniques that synthesise various studies found that infrastructure development increases OECD exports by about 0.6 percent and imports by about 0.3 percent through reduction in transport costs.

2.5 Overview of Literature

The reviewed literature indicates that studies on the role of air transport services on trade flows are generally scarce. However, literature on the effects of other transport means: road, water, and rail transport services on trade is relatively available. Very little has been done for air transport services. Where air transport service sector has been considered, little has been done at sectoral and product level. Sector specific literature in this area is largely missing. Sectoral analysis is very important given that the elasticity of trade to transport services varies with industries. Whereas other sectors are elastic to air transport service, horticultural goods and health related pharmaceutical goods for instance, are inelastic. Where product data is available, product specific studies are most preferred. This study is among the few to consider the effects of air transport service at a sector-specific (pharmaceutical sector) level.

33 Consists of annual observations covering the period of 1970 to 1990.

34 Belgium/Luxembourg, France, Germany, Italy, Netherlands, and the UK

35 Include Finland, Norway, and Sweden in addition to the data for the six core EU countries.

3. Methodology and Data

The study applied two different methodologies to achieve the two study objectives. To achieve objective number 1[36] and 2[37], the study applied the canonical gravity model introduced by Isard (1954) and the descriptive statistical analysis respectively.

3.1 The Gravity Model Method

The traditional gravity model has for decades, been successfully used to analyze varying types of flows including migration, recreational traffic, commuting (Ravenstein, 1885; Stewart, 1947) and international trade flows and the interaction of trade forces and spatial concentration (Isard, 1954; Tinbergen, 1962; Capoani, 2023). Based on Isard (1954)'s analytical gravity concepts from physics, Tinbergen in 1962 proposed an econometric and empirical formular to estimate bilateral trade flows between two trading countries. The model has been constantly reviewed by several scholars (Philbrick, 1973a; Anderson, 1979; Anderson, 2011; Yotov et al., 2016; Head, 2003; Capoani, 2023). As proposed by Tinbergen (1962), the gravity model in its basic form is specified as follows:

$$TF_{ij} = C.\frac{M_i M_j}{D_{ij}} \quad (7)$$

Where TF_{ij} stand for bilateral trade flows from country i to country j, C is a constant, Dij refers to bilateral distance between country i and country j and $M_i\, M_j$ denotes economic dimensions of the two trading countries.

Gravity models are estimated both on cross-section and panel data. While cross-section models have the advantage of a much lower data requirement, panel data models or repeated cross sections as sometimes referred, contains more information, more variability, and more efficiency than cross-sectional data. Because of data limitation[38], this study applies cross-sectional data analysis using 2021 data across 19 COMESA Member States[39].

The empirical model used in this study follows Silva & Tenreyro (2006). Using bilateral pharmaceutical trade data, the regression equation is specified in multiplicative form as follows:

$$TF_{ij} = \exp(\beta_0 + \beta_1\varphi) + \varepsilon \quad (8)$$

Where ϕ is a vector of traditional gravity variables which include distance, importer and exporter GDPs, common language, common colony, and contingents among other variables. To empirically examine the impact of air transport service on intra-COMESA pharmaceutical trade, the study augments the traditional gravity model with variables to capture COVID-19 and air transport service. The study used government stringency index and air connectivity index to capture COVID-19 and air transport service respectively. The augmented gravity model used in this study is specified as follows:

$$TF_{ij} = \exp(\beta_0 + \beta_1\varphi + \beta_2\gamma) + \varepsilon \quad (9)$$

36 Objective number 1 is to examine the effects of air transport service on trading of pharmaceutical goods in the COMESA region,
37 Objective number 2 is to analyze the state of air infrastructure quality and air connectivity in the COMESA region.
38 Data on air transport service indicator (international air connectivity) is available for 2019 only.
39 Countries were selected based on data availability.

Where γ is a vector of COVID-19 and air transport service indicators. Using the PPML estimator[40], the study estimated the following equation in a multiplicative form:

$$TF_{ij} = Exp(\beta_0 + \beta_1 GDP_i + \beta_2 GDP_j + \beta_3 Dist_{ij} + \beta_4 CL_{ij} + \beta_5 CC_{ij} + \beta_6 Cont_{ij} + \beta_7 COV_i + \beta_8 COV_j + \beta_9 Conn_i + \beta_{10} Conn_j) + \varepsilon \quad (10)$$

Where TF_{ij} refers to bilateral pharmaceutical trade between country i and j country ; GDP_i and GDP_j represent economic mass of the exporting country and the market potential of the importing country respectively. $Dist_{ij}$ is the geographical distance between bilateral trading partners; CL_{ij} stand for common official language between trading partners; CC_{ij} denotes countries colonized by the same colonial masters whereas $Cont_{ij}$ stands for sharing a common border; COV_i and COV_j stands for the exporter and importer COVID-19 stringency index; $Conn_i$ and $Conn_j$ refers to the exporting and importing country's connectivity index respectively and to are parameters β_o to β_{10} be estimated. Equation 10 was estimated to establish the impacts of air transport service on intra-COMESA pharmaceutical trade.

3.2 Data sources and variable measurements

The study used 2021 annual pharmaceutical trade data for 19 COMESA countries[41]. Countries included in the study were chosen based on data availability. Trade data, because they are measured in the same units were obtained from COMSTAT Database as well as ITC Trade Map. Variables that capture distance, common colony, common language as well as common border were accessed from ***Centre d'Etudes Prospectives et d'Informations Internationales (CEPII).*** GDP data for 2021 was downloaded from World Development Indicators (WDI) whereas the COVID-19 stringency index, the connectivity index and air infrastructure quality variables were accessed from ourworldindata.org database, the International Air Transport Association (IATA) 2019 report and the global economy air infrastructure quality rankings. Table 1 provides variable description, expected signs of the coefficients as well as the unit of measurement.

Table 1: Variable description, measurement and expected sign.

Variable Symbol	Variable Name	Measurement	Expected Sign
TF_{ij}	Bilateral Trade	US$	
GDP_i	Exporter Gross Domestic Product	US$	Positive
GDP_J	Importer Gross Domestic Product	US$	Positive
$Dist_{ij}$	Distance between country and country	Kilometres	Negative
CL_{ij}	Common Language between country and country .	1 for common language, 0 otherwise	Positive
CC_{ij}	Common Colon between country and country .	1 for common Colonizer, 0 otherwise	Positive

40 The PPML estimator was preferred to address the problem of zero trade flows and heteroscedasticity.
41 Burundi; DRC; Djibouti; Egypt; Eswatini; Ethiopia; Kenya; Libya; Madagascar; Malawi; Mauritius; Rwanda; Seychelles; Somalia; Sudan; Tunisia; Uganda; Zambia and Zimbabwe.

$Con't_{ij}$	Border sharing between country and country .	1 for common border, 0 otherwise	Positive
COV_i	Exporter COVID-19 Stringency Index	Index	positive
COV_{ij}	Importer COVID-19 Stringency Index	Index	positive
$Conn_i$	Exporter Connectivity	Index	Positive
$Conn_j$	Importer Connectivity	Index	Positive

Source: *Author Compiled*

3.3 Estimation Technique

Over the years, researchers have proposed several approaches to handle the presence of zero trade flows. One of the common approaches involves adding a very small, and in fact completely arbitrary value to replace the zero trade flows. Other methods include the use of the Tobit estimator, the Helpman-Melitz-Rubinstein, (2008) two stage model and the use of a Poisson Pseudo Maximum Likelihood (PPML) estimator. For convenience reasons, this study used the PPML estimator to handle the presence of zero trade flows. As a result, the study estimated the gravity model in a multiplicative form instead of logarithmic form.

Fifty-three percent of the total observations in this study contained zero trade flows. Monte Carlo simulations argued that PPML performs very well even when the proportion of zeroes is large. These zeros are mainly a result of rounded trade flows or countries do not trade with each other (Fink & Primo Braga, 1999). Exclusion of these zeros is not recommended as this would lead to a potential sample selection bias.

According to Silva & Tenreyro (2006), cross-section data is often plagued with heteroscedasticity, which in this study was addressed using the PPML estimator. Besides, heterogeneity is also a common problem arising from country specific attributes such as geography and differences in trade policies among others. Though the study focuses on COMESA Member States, it acknowledges country specific differences mainly due to differences in trade policies resulting from bilateral and overlapping Regional Trade Agreements (RTAs). The heterogeneity problem in this study was addressed using the exporter and importer pair fixed effects.

4. Presentation and Discussion of Results

4.1 Descriptive Statistics

On average intra-pharmaceutical bilateral trade flows in the COMESA region reached US$ 1.2 million in 2021 as shown in Table 2. The variation in bilateral trade flows is too large as shown by a large standard deviation of US$ 4.2 million. Table 2 shows that some COMESA Member States traded zero pharmaceutical goods in 2021. Zero trade flows in COMESA countries may be due to rounded-off trade flows, omissions, or non-reported data. However, the maximum pharmaceutical goods traded by COMESA Member States in 2021 reached US$ 3.1 million with a variance of US$ 1.7 million. The graph further shows that trade flow data is positively skewed and highly peaked as indicated by kurtosis of US$ 29.3 million.

Table 2: Descriptive analysis results

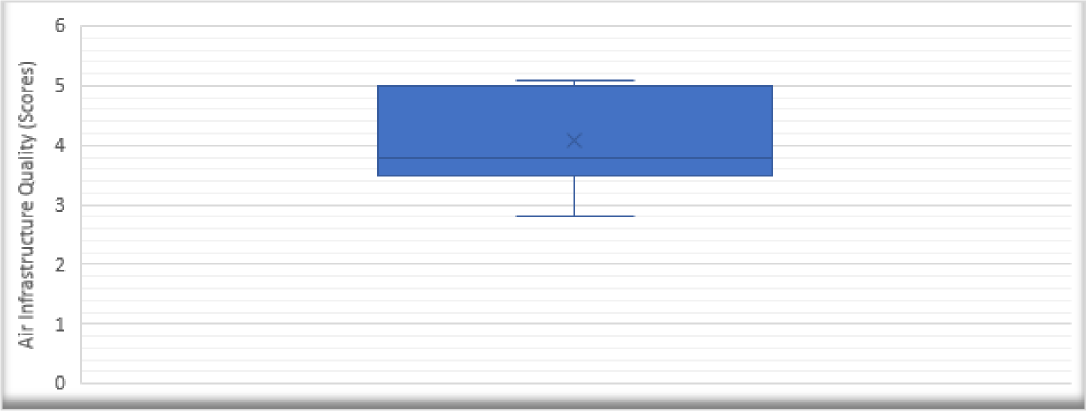
Variable	Mean	Coff. of Var.	Std. Dev.	Min.	Max.	Skew-ness	Kurtosis
Trade Flows	1.18	352.54	4.16	0	3.14	4.93	29.32
Exporter GDP	5.08	175.59	8.92	1.45	4.04	2.04	6.47
Importer GDP	5.08	175.59	8.92	1.45	4.04	2.04	6.47
Common Language	0.55	90.91	0.50	0	1	-0.20	1.04
Common Colony	0.30	153.33	0.46	0	1	0.88	1.78
Contingent	0.13	261.54	0.34	0	1	2.22	5.92
Distance	3034.13	55	1668.87	180.01	8053.87	0.73	3.11
Exporter COVID-19	48.74	28.64	13.96	16.09	71.25	-0.51	2.65
Importer COVID-19	48.74	28.64	13.96	16.09	71.25	-0.51	2.65
Exporter Air Con-nectivity	12.33	13.54	1.67	8.62	15.30	2.54	9.33
Importer Air Con-nectivity	12.33	13.54	1.67	8.62	15.30	2.54	9.33

Source: *Author Compiled using data from COMSTAT Database, ITC Trade Map, CEPII, WDI and IATA.*

Table 2 further indicates that 55 percent of the COMESA Member States speaks a common official language whereas 30 percent and 13 percent were colonized by the same Colonizer and share common border respectively. The COVID-19 stringency applied by COMESA exporting and importing countries averaged 49 in 2021 measured on a scale of 0 to 100 (where 100=strictest). The distance between COMESA Member States as well as their GDPs averaged 3034 kms and US$ 5.8 million in 2021 respectively.

The state of air infrastructure quality in COMESA is visually presented on a box plot. A box plot is a tool used to analyse data. Figure 7 shows that the lower and upper extreme scores for air infrastructure quality in COMESA on a score range of zero to 7, where zero means poor quality air infrastructure and 7 means best quality air infrastructure are 2.8 and 5.1 scores. The median score for the region is 4.1 scores. This implies that other COMESA Member States scored as low as 2.8, whereas the best regional performers scored 5.1. Generally, the figure depicts that the quality of air infrastructure in COMESA is low.

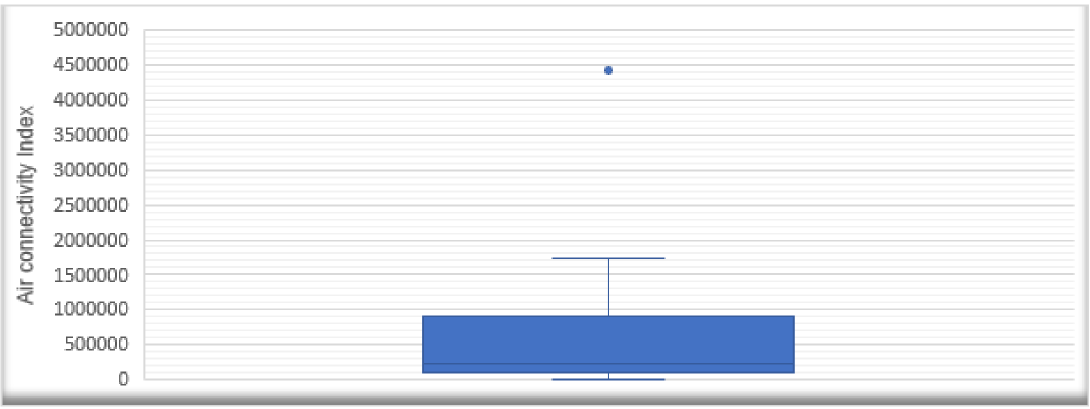
Figure 7: Distribution of quality air infrastructure in the COMESA region



Source: *Author Compiled using data from the World Economic Forum (WEF).*

Figure 8 presents the air connectivity situation in the COMESA region. The figure indicates that air connectivity in the COMESA region is low with a lower and upper extreme connectivity index of 0.005 million and 4.5 million respectively. Air connectivity in COMESA, as depicted in Figure 8 is generally low.

Figure 8: Air connectivity in the COMESA region



Source: *Author Compiled using data from IATA*

4.2 Correlation Analysis

To understand the association between variables on the gravity model, a correlation analysis was conducted. Conducting correlation analysis enables the identification of highly correlated variables in a model. If not controlled for, multicollinearity may produce misleading results. Any correlation coefficient equal to or greater than 0.8 indicate likely multicollinearity problem. Table 3 presents the correlation results for variables included in the gravity model.

Table 3: Correlation analysis results

Variable	T_{ij}	GDP_i	GDP_j	CL_{ij}	CC_{ij}	Cov_i	$Dist_{ij}$	$Conn_i$	$Conn_j$	Cov_i	Cov_j
Trade flows	1.0000										
Exporter GDP	-0.0412	1.0000									
Importer GDP	-0.0085	-0.0556	1.0000								
Common Language	0.1770	0.1056	0.1056	1.0000							
Common Colony	0.0902	0.0530	0.0530	0.3845	1.0000						
Contingent	0.3751	-0.1246	-0.1246	0.1020	0.0931	1.0000					
Distance	-0.2452	0.2466	0.2466	-0.2994	-0.2345	-0.4036	1.0000				
Exporter Connectivity	0.1478	0.0852	-0.0047	-0.0895	-0.1609	0.0155	0.1576	1.0000			
Importer Connectivity	0.1876	-0.0047	0.0851	-0.0895	-0.1609	0.0155	0.1576	-0.0556	1.0000		
Exporter COVID-19	0.0072	0.5230	-0.0291	0.1307	0.0673	-0.1100	0.1688	0.0315	-0.0018	1.0000	
Importer COVID-19	0.0395	-0.0291	0.5230	0.1307	0.0673	-0.1100	0.1688	-0.0018	0.0315	-0.0556	1.0000

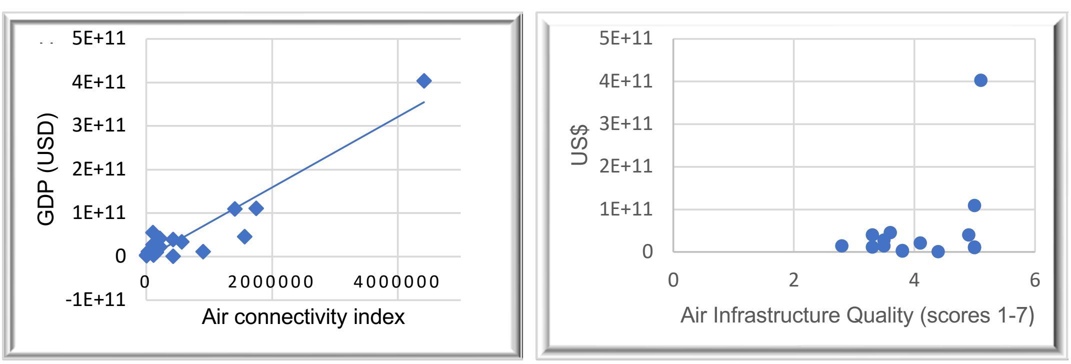
Source: *Author compilation using data from COMSTAT Database, ITC Trade Map, CEPII, WDI and IATA.*

The correlation analysis indicates that intra-COMESA pharmaceutical trade flows is positively correlated with the exporter and importer connectivity variables; exporter and importer COVID-19 variables, common language, common colony, contingent but negatively correlated with distance, exporter, and importer GDPs. The association suggested by the matrix is consistent with the theory for most variables in the model save for the exporter and importer GDPs.

The scatter plot in Figure 9 presents the relationship between air connectivity and GDP as well as air infrastructure quality and GDP. Panel 9(a) indicates a positive relationship between air connectivity and GDP. This implies that low levels of GDP are associated with low air connectivity. The figure also indicates that COMESA countries with low GDP are less connected.

Figure 9: Connectivity, GDP and Infrastructure quality

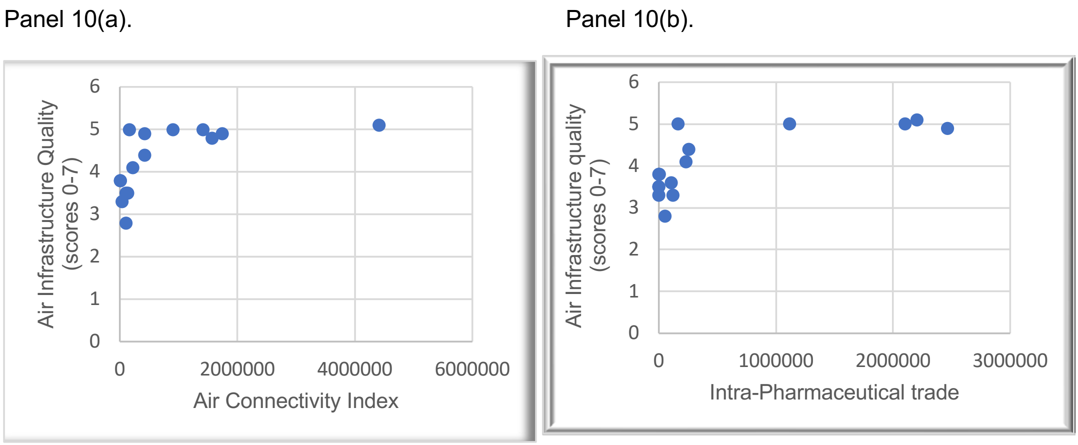
Panel (a) panel (b)



Source: *Author Compiled using data from IATA, COMSTAT Database, ITC Trade Map and WD.*

Panel 9(b) depicts similar indications. COMESA Member States with low GDP have got relatively poor air infrastructure. The insinuation suggests that national growth is associated with the provision of quality air infrastructure. Also, Panel 10(a) and 10(b) present the relationship between air connectivity, air infrastructure quality and intra-COMESA pharmaceutical trade. Panel 10(a) indicates that low air infrastructure quality is associated with low air connectivity. This suggests that improving air infrastructure quality is likely to lead to an improvement in air connectivity in the COMESA region.

Figure 10: Infrastructure quality, air connectivity and intra-COMESA trade



Source: *Author compilation using data from IATA, COMSTAT Database, ITC Trade Map and WDI*

Panel 10(b) shows that low infrastructure quality is associated with low pharmaceutical trade in the COMESA region. This suggests that improving air infrastructure quality increases air connectivity which stimulates intra-COMESA trade in pharmaceutical goods.

4.3 Empirical Results

Diagnostic Tests

Multicollinearity Test

To detect the possible existence of the multicollinearity problem, the study used the variance inflation factor (vif) method. According to James et al., (2013), a vif of 1 indicates the complete absence of collinearity. A vif between 5 and 10 indicate moderate correlation whereas a value larger than 10 indicates an unacceptable amount collinearity. Figure 11 presents the Variance Inflation Factor (VIF).

Figure 11: Variance Inflation Factor (VIF)

Variable	VIF	1/VIF
Distance	1.64	0.610133
Exporter GDP	1.48	0.675971
Importer GDP	1.48	0.675971
Com. Language	1.36	0.737385
Com. Colon	1.25	0.800381
Cont'	1.22	0.818264
Exporter connectivity	1.07	0.935836
Importer connectivity Exporter COVID-19	1.07 1.41	0.935836 0.708787
Importer COVID-19	1.41	0.708787
Mean VIF	1.34	

Source: *STATA output*

Heteroscedasticity Test

To detect the presence of the heteroscedasticity problem, the study used the Breusch-Pagan test. The test uses the chi-square test statistic and a corresponding p-value to determine the presence of heteroscedasticity. If the p-value is significant, it indicates the presence of heteroscedasticity. The chi2(1) of 1.10 and prob > chi2 of 0.2941 provides sufficient evidence of the absence of heteroscedasticity.

Table 4 presents the gravity model regression results. The results show that the coefficients of exporter and importer air connectivity are statistically significant at 1 percent and carries the expected signs. These results are consistent with the theoretical prediction in Principal (2009) which anticipated a positive association between air transport service and intra-COMESA pharmaceutical trade.

Table 4 shows the results from the regression model with the PPML estimator.

Variable	Est. Coeff.
Exporter GDP	-0.0002 (0.000)
Importer GDP	-0.0002 (0.000)
Distance	-0.0010 (0.000)
Common Language	0.8398 (0.013)
Common Colon	-1.1144 (0.232)
Contingent	-0.0601 (0.859)
Exporter COVID-19	0.0424 (0.077)
Importer COVID-19	0.0535 (0.010)
Exporter Air Connectivity	6.5100 (0.000)
Importer Air Connectivity	6.0100 (0.000)
Constant	10.2344 (0.000)
Observations	342
Adjusted R-Squared	0.8088

Source: Regression Results P-Values in parentheses

The results indicate that a 1 unit increase in air connectivity by COMESA exporting and importing countries would stimulate intra-COMESA pharmaceutical trade by 6.5 units and 6 units respectively. This implies that a 1 unit increase in air connectivity by all COMESA Member States would induce intra-COMESA trade in pharmaceuticals by 12.5 units. These results concur with Brugnoli et al. (2018), Kumar et al. (2023), Andriamananjara (2004), Button (2010) and the World Trade (2005) studies which found a positive relationship between air transport services and trade.

Similarly, Brugnoli et al. (2018) obtained a positive and statistically significant relationship between civil aviation and trade between Italy and 30 European countries. Results of this study and Brugnoli et al. (2018) however differ in magnitude. Difference in magnitude may be due to several factors. Firstly, this study is sector-specific whereas Brugnoli et al. (2018) study focused on aggregate products. Moreover, differences may be due to variations in environmental settings. Whereas this study has been conducted in Africa, COMESA in particular, Brugnoli et al. (2018) focused on developed countries, particularly the European countries.

The results further indicate that the estimated coefficient for distance is negative and statistically significant at 1 percent implying that a 1 unit (km) increase in distance would reduce intra-COMESA pharmaceutical trade by 0.001 units. These findings are also in agreement with Brugnoli et al., (2018), who similarly obtained a negative and statistically significant effect of distance on civil aviation and trade relationship between Italy and 30 European countries. However, the coefficients of the exporter and importer GDPs are negative and statistically significant at 1 percent. This is in contrast with Brugnoli et al. (2018) who obtained positive and statistically significant effect of exporter GDP on Italian civil aviation and trade relationship with 30 European countries. The results indicate that a 1 unit increase in exporter GDP would reduce intra-COMESA pharmaceutical trade by 0.0002 units. Similarly, an increase in importer GDP of 1 unit would result in 0.0002 units decline in intra-COMESA pharmaceutical trade.

Table 4 further indicates that coefficients of the importer and exporter COVID-19 variables are positive and statistically significant at 5 percent and 10 percent respectively. This implies that a 1 unit increase in the importer and exporter government stringency would lead to 0.05 and 0.04 units increase in intra-COMESA pharmaceutical trade. This may suggest that an increase in COVID-19 severity would compel COMESA Member States to increases their stringency measures and trade more of pharmaceutical goods to curtail further spreading of the pandemic.

Although Kumar et al. (2023) finds similar results, the study used a qualitative approach and focused on the role of transport in international trade in general unlike this sector-specific (air transport) study. Similarly, Andriamananjara (2004), Button (2010) and the World Trade Report (2005) concurred using analytical study methodologies that transport service enhances trade.

Robustness Checks

To check the robustness of the results, the same model which was estimated with the PPML estimator was estimated using the Ordinary Least Square (OLS) method. Table 5 shows regression results with the OLS estimator. Similar to the PPML regression model, the results show that the coefficients of exporter and importer air connectivity are statistically significant at 1 percent and carries the expected signs. These results indicate that a 1 percent increase in air connectivity by COMESA exporting and importing countries would stimulate intra-COMESA pharmaceutical trade by 3.7 percent and 6 percent respectively. This implies that a 1 percent increase in air connectivity by all COMESA Member States would induce intra-COMESA trade in pharmaceuticals by 9.7 percent. The regression results for other gravity model variables namely exporter GDP, importer GDP, Distance, Common Language, Common Colony, Contingent as well as exporter and importer COVID-19 are similar with respect to significance as well as variable signs save for the magnitude of the coefficience.

Table 5 shows the results from the regression model with the OLS technique.

Variable	Est. Coeff.
Exporter GDP	-0.0004 (0.002)
Importer GDP	-0.0004 (0.002)
Distance	-0.0016 (0.000)
Common Language	1.9774 (0.057)
Common Colon	5.2047 (0.000)
Contingent	1.4411 (0.325)
Exporter COVID-19	0.0533 (0.159)
Importer COVID-19	0.1013 (0.008)
Exporter Air Connectivity	3.6800 (0.000)
Importer Air Connectivity	4.9700 (0.000)
Constant	-8.2105 (0.002)
Observations	342
Adjusted R-Squared	0.4124

Source: Regression Results **P-Values in parentheses**

5. Conclusion and Policy Implications

This study investigated the effects of air transport service on intra-COMESA pharmaceutical trade. Intra-pharmaceutical trade is key in the COMESA region considering high incidence of natural and manmade disasters which curtail growth and development of the region. This study, thus, analysed the state of air infrastructure quality and air connectivity in the COMESA region. The study used 2021 panel data for 19 COMESA Member States taken from COMSTAT Database and the ITC Trade Map, CEPII data to capture distance, common colony and common language whereas GDP, COVID-19 stringency index and the air connectivity index data were accessed from ourworldindata.org database, the WDI and IATA reports respectively.

The study applied the gravity model and the PPML estimator and found that air transport service positively affects intra-COMESA pharmaceutical trade. A 1 unit increase in air connectivity by COMESA exporting and importing countries would stimulate intra-COMESA pharmaceutical trade by 6.5 units and 6 units respectively. This implies that a 1unit increase in air connectivity by all COMESA Member States would induce intra-COMESA trade in pharmaceuticals by 12.5 units. Results further indicate that the quality of air infrastructure in COMESA is 0.45 scores below the global average score of 4.55.

The study further indicates that the estimated coefficient for distance is negative and statistically significant at 1 percent. Similarly, the coefficients of the exporter and importer GDPs are negative (against theoretical prediction) and statistically significant at 1 percent. The results further indicate that the coefficients for common colony and contingent are insignificant in influencing intra-COMESA pharmaceutical trade whereas coefficients of the importer and exporter COVID-19 variables are positive and statistically significant at 5 percent and 10 percent respectively.

To improve intra-pharmaceutical trade, the COMESA region is recommended to increase country-to-country air transport connectivity with other regional trading partners. This can be achieved through investments in projects aimed at increasing the availability and quality of air infrastructure such as fleets of aircraft and airports across COMESA Member States.

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The Effect of Transport Infrastructure Quality on Intra-COMESA Trade

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Abstract

This study applied the augmented gravity model to analyse the effect of transport infrastructure quality on intra-COMESA trade for a panel of 21 COMESA Member States using the Poisson Pseudo Maximum likelihood (PPML) estimators over the period from 2005 to 2022. The study's findings show that the estimated coefficients of Transport Infrastructure Development, Quality of Transport Infrastructure, and Quality of Trade and Transport Related are positive and statistically significant. For exporting countries, the corresponding coefficients for Transport Infrastructure Development, Quality of Transport Infrastructure, and Quality of Trade and Transport Related are 0.270, 0.745, and 0.738, whereas for importer countries, they are 0.167, 0.262, and 0.466. Quantitative analysis of the Standard Modal Freight Transport shows that the coefficients of quality of roads, railroads, ports, and airports are 0.379, 0.582, 0.488, and 0.256 for exporter countries, respectively. The coefficients of quality roads, railroads, and ports for importer countries are 0.153, 0.306, and 0.328 respectively. In addition to modal freight analysis, the study investigated the effects of bilateral marine distance between COMESA Member States and distance to the nearest seaport from capital city. The coefficient estimated for bilateral marine distance is negative (-0.282) and statistically significant. The estimated coefficients for distance to the nearest seaport for both exporters (-0.199) and importers (-0.136) are negative and statistically significant. The major policy implication arising from the study is that Member States should invest in road infrastructure in order to increase access to paved and non-paved roads and focus on improving the quality of the existing roads, railroads, ports and airports.

***Key Words**: Gravity Model; Transport Infrastructure Quality; Poisson Pseudo Maximum likelihood*

1. Introduction

The Common Market for Eastern and Southern Africa (COMESA) consistof 21 Member States which joined forces to advance regional integration through commerce and the development of human and natural resources for the benefit of everyone. COMESA was first created in 1981 as the Preferential Trade Area for Eastern and Southern Africa (PTA) in accordance with the Final Act of Lagos and the Lagos Plan of Action of the Organization of African Unity (OAU). The PTA was created to benefit from a wider market, share the region's common history and future, and promote greater social and economic cooperation. In 1994, the PTA changed its name to COMESA.

Following 16 years of progressive trade liberalization through the removal of intra-trade tariffs, COMESA established a Free Trade Area on October 31, 2000 (COMESA, 2018). About 16 of the 21 participating nations were part of the FTA as of December 2022. Regarding their involvement in the FTA, the other five Member States—Ethiopia, Eritrea, Eswatini, DR Congo, and Somalia—were at varying stages. The COMESA Rules of Origin are used to determine whether goods produced in the COMESA region are eligible for preferential treatment within the FTA (COMESA, 2018).

1.1.1 COMESA Trade Performance

COMESA's global exports grew by 73.3 percent from US$90.3 billion in 2020 to US$156.4 billion in 2021. Compared to the 2019 figure of US$123.4 billion before COVID-19, COMESA global exports have grown by 26.7 percent. The huge growth of 73.3 percent in COMESA's global trade shows the region's ability to recover from the adverse trade effects of COVID-19. The countries that experienced huge percentage growth in exports trade to the world include Libya, Eritrea, and Somalia. However, in value terms, Libya, Egypt, and DR Congo are the leading exporters. Uganda is the only country that experienced a decline in global exports.

As shown in Table 1 intra-COMESA exports increased by 32.0 percent from US$9.7 billion in 2020 to US$ 12.8 billion in 2021 (COMSTAT, 2023). Compared to the 2019 figure of US$ 10.9 billion, intra-COMESA exports grew by 17.4 percent. The countries that experienced huge percentage growth in intra-COMESA exports are Djibouti, Libya, and Sudan. Countries such as Eritrea, Seychelles, Somalia, and Zimbabwe experienced a decline in intra-COMESA trade, which could be attributed to the prolonged adverse trade effects of COVID-19. However, it important to note that the figures used only capture the formal trade, excluding informal cross-border trade which contribute a significant share of regional trade.

Table 1: Global and intra-COMESA export performance: 2020 - 2021

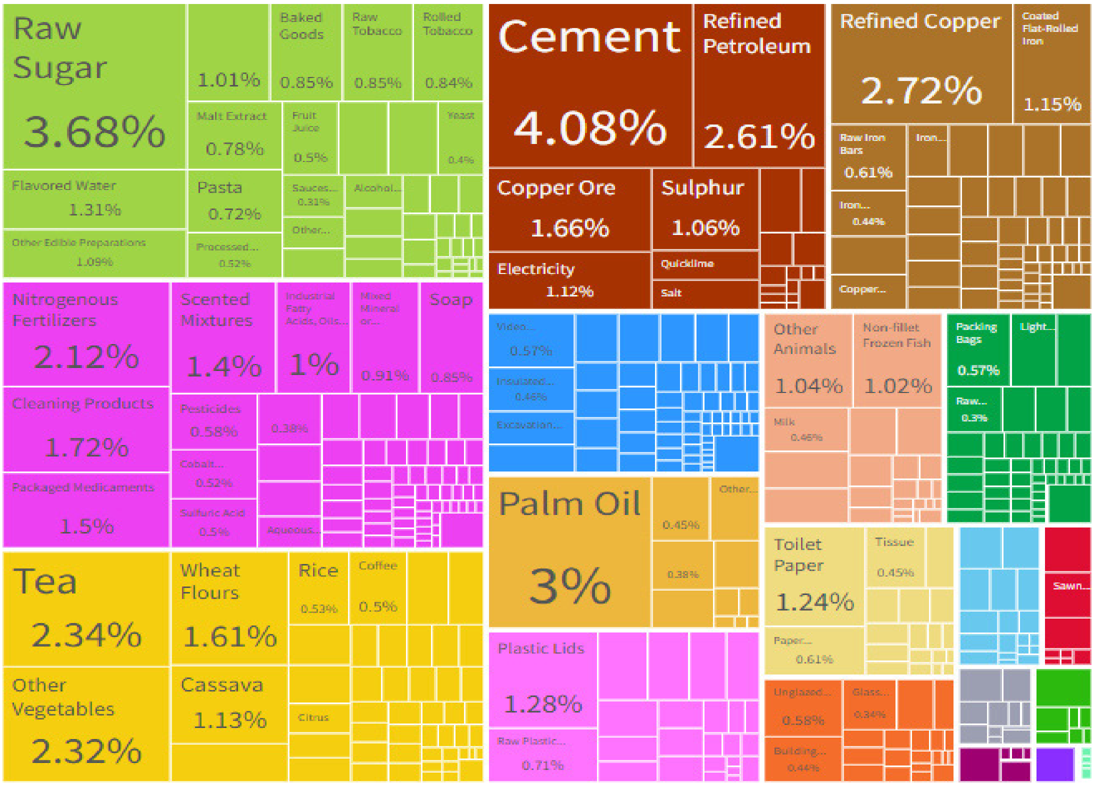
	Global Exports			**Intra-COMESA exports**		
	Million US Dollars		Global Exports Growth	Million US Dollars		Intra-COMESA Exports
	2020	2021		2020	2021	
Burundi	101	166	64.4%	45	57	27%
Comoros	21	34	61.9%	2	3	50%
DR Congo	14056	24125	71.6%	1291	1513	17%
Djibouti	272	317	16.5%	13	167	1185%
Egypt	23919	40555	69.6%	1954	2838	45%
Eritrea	2	511	25450.0%	1	0	-100%
Eswatini	1752	2068	18.0%	216	240	11%
Ethiopia	2243	2843	26.7%	447	521	17%
Kenya	6532	6755	3.4%	1775	2086	18%
Libya	2256	28064	1144.0%	81	255	215%
Madagascar	1380	2035	47.5%	45	53	18%
Malawi	771	998	29.4%	160	206	29%
Mauritius	1550	1679	8.3%	195	221	13%
Rwanda	1436	1447	0.8%	473	660	40%
Seychelles	985	1729	75.5%	17	14	-18%
Somalia	37	386	943.2%	6	3	-50%
Sudan	3532	5184	46.8%	303	724	139%
Tunisia	13849	16801	21.3%	564	792	40%
Uganda	3379	3285	-2.8%	608	755	24%
Zambia	7817	11143	42.5%	1271	1577	24%
Zimbabwe	4395	6322	43.8%	235	83	-65%
COMESA	90253	156444	73.3%	9700	12768	32%

***Source**: COMStat, 2023*

In 2021, the top external exports of COMESA were crude petroleum ($32.4 billion), gold ($12.7 billion), refined copper ($11.7 billion), raw copper ($7.12 billion), and refined petroleum ($6.02 billion). The principal destinations were China ($20.4 billion), United Arab Emirates ($15.6 billion), Italy ($14.6 billion), France ($8.86 billion), and United States ($8.83 billion).

Figure 1 shows that the top 10 intra-COMESA exports in 2021 were cement ($473m), raw sugar ($428m), palm oil ($348m), refined copper ($316m), refined petroleum ($303m), tea ($271m), other vegetables ($269m), nitrogenous fertilizers ($246m), cleaning products ($200m) and wheat flours (187m). The major intra-COMESA export destinations were DR Congo ($1.97B), Libya ($1.42B), Kenya ($1.13B), Uganda ($983M), and Egypt ($899M) in the same year.

Figure 1: Composition of intra-COMESA exports - 2021



Source: *https://oec.world/en/profile/international_organization/comesa*

Infrastructure development has been identified as a key priority in COMESA, requiring particular emphasis. Enhancing physical regional connectivity and strengthening infrastructure integration could effectively lower operating costs and boost competitiveness within the region. As a result, a corridor-based, comprehensive strategy for infrastructure development has been adopted. Several cross-border corridors including COMESA Member States have been established (*See Table 2 below*). These corridors provide opportunities for reducing transportation and shipping costs. In addition, imports and exports transit times will be lowered, which is a prerequisite for increasing intra-COMESA trade. However, a sufficient condition is proper focused management of corridors – this yields the expected benefits. Cross-border road corridors not only improve trade and regional integration, but they also provide access to social services and markets, which helps reduce poverty.

Table 2: Cross border corridors in COMESA region

Cross-Border Road Corridors	Anchor Seaport	COMESA Countries included	Outcomes
Nacala Corridor	Nacala (Mozambique)	Malawi, Mozambique and Zambia (Connecting Zambia & Malawi to the Indian Ocean)	Total time spent traveling on the relevant sections: 30 hours prior, 15 hours in 2017. Trucks now arrive at the Malawi border crossing in three hours instead of twelve hours as they did in 2017. Mozambique saw a 36% decrease in vehicle running expenses, while Malawi saw a 20% decrease.
North-South Corridor	Durban (South Africa)	Botswana, Democratic Republic of the Congo (D.R.C.), Burundi, Rwanda, Uganda, Zambia, Zimbabwe, South Africa	The East African Community's (EAC) commercial exchanges have grown in value from US$500 million in 2011 to US$650 million in 2020. A light vehicle's average duration at the Burundi/Rwanda border decreased from 7 hours in 2011 to 3.5 hours in 2016. The cost of running a vehicle decreased from US$ 0.84 per km in 2011 to US$0.35 per km in 2016.
Northern Corridor	Mombasa (Kenya)	Kenya, Uganda, Rwanda, Burundi, South Sudan and the Democratic Republic of Congo (DRC).	Trade volume between Mombasa Port and Uganda is expected to rise by 20% between 2017 and 2028. Operating expenditures for vehicles decreased from $0.38 per km in 2018 to $0.16 per km in 2022.
LAPSSET Corridor	Lamu (Kenya)	Kenya , Ethiopia, South Sudan	Trade between Kenya and Ethiopia increase from US$ 35 to 175 million by the end of 2019
Beira Corridor	Beira (Mozambique)	Mozambique, Malawi, Zimbabwe, Zambia, DRC	
Central Corridor	Dar es Salaam (Tanzania)	Tanzania, DRC, Rwanda, Burundi	The Government of Tanzania's transport lab recommendations known as the "Big Results Now" (BRN) Initiative notes that the initiative will lower the number of official inspections for transit trucks along the Central Corridor from 17 to 3. The cost of a visa between Tanzania, Uganda, and the Democratic Republic of the Congo has been reduced from $100 for seven days to $50 for a month.
Dar es Salaam Corridor	Dar es Salaam (Tanzania)	Kenya, Tanzania, Zambia, DRC	Volume of trade between Zambia and Kenya to rise to 3MT in 2020 from 0.4MT in 2011.

Trans-Tunisia Corridor		Tunisia, Egypt and Libya	Between 2015 and 2020, the daily flow of commodities moved by road increased by an average of 8% annually.
Djibouti Corridor	Djibouti (Djibouti)	Uganda, South Sudan, Sudan, Ethiopia and Djibouti	To expand access to local, regional, and global markets, lower transportation costs, increase regional connectivity, boost regional trade, encourage tourism, and promote regional cooperation and integration

***Source**: African Development Bank, 2019*

The African Development Bank developed a "Transport Composite Index" which is used to monitor and assess transport infrastructure development progress across the African continent. The index comprises total paved roads (km per 10 000 inhabitants) as a proxy of access to paved road network; and total road network in km (total road network including both paved and non-paved roads). Table 3 below shows Transport Composite Index for COMESA Member States. Analysis shows that only four countries have high access to paved road systems – these include Egypt, Libya, Mauritius, and Seychelles. The index shows that several countries have low access to paved road networks with scores less than the lower quartile of 25. The countries with the lowest access to paved road networks include Sudan, Somalia, and DR Congo with scores below 2. Further analysis of the Transport Development Index reveals that there are variations in the quality of infrastructure in COMESA. These variations could significantly impede trade since trade depends on both internal and cross-border transport systems

Table 3: Transport Infrastructure Development Index (2010 – 2022)

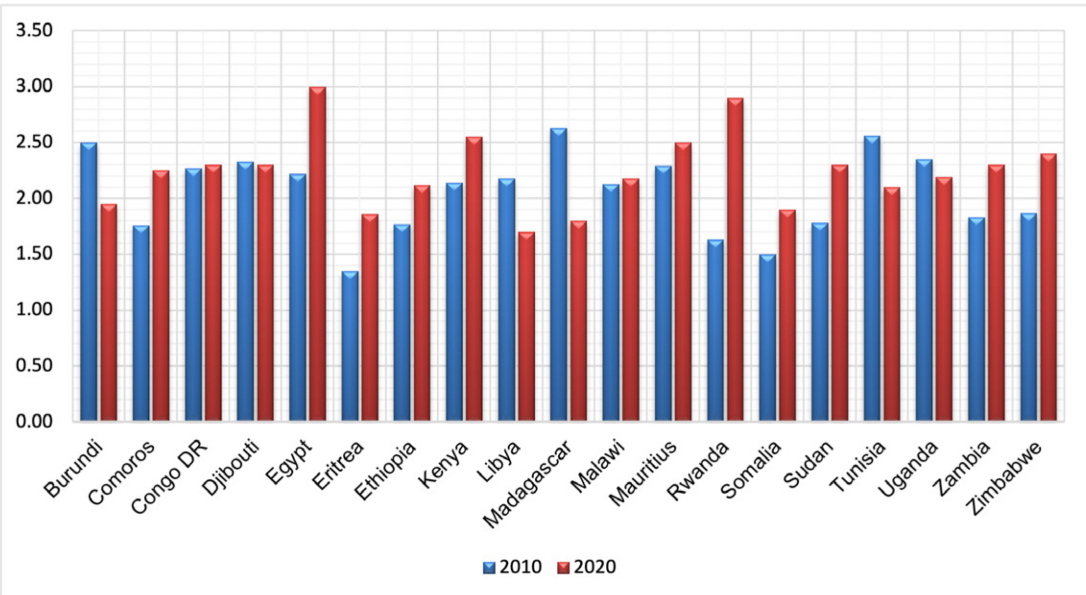
Country	2010	2012	2014	2016	2018	2020	2022
Burundi	9.7	9.4	8.7	8.6	8.7	8.7	8.6
Comoros	16.4	16.2	15.5	15.2	15.0	14.8	14.7
DR Congo	1.7	1.6	1.5	1.5	1.5	1.5	1.5
Djibouti	10.1	10.0	10.1	9.9	9.7	9.3	9.2
Egypt	**54.5**	**53.9**	**53.7**	**53.1**	**52.6**	**54.9**	**54.5**
Eritrea	1.6	1.6	1.5	1.5	1.5	2.0	3.3
Eswatini	9.1	9.0	8.8	8.7	8.5	13.2	13.1
Ethiopia	1.8	1.8	1.7	1.7	2.2	2.1	2.1
Kenya	5.1	4.8	12.1	11.9	11.3	10.5	10.4
Libya	**53.2**	**52.7**	**41.8**	**42.1**	**41.8**	**40.4**	**40.0**
Madagascar	3.3	3.2	3.2	3.1	3.0	2.9	2.9
Malawi	5.5	5.3	5.1	4.9	3.8	3.8	3.7

Mauritius	**36.6**	**36.2**	**35.4**	**35.1**	**36.7**	**36.7**	**36.6**
Rwanda	13.8	13.4	12.5	12.3	11.7	11.6	11.5
Seychelles	**53.3**	**52.8**	**51.9**	**51.6**	**51.8**	**51.9**	**51.7**
Somalia	2.3	2.3	2.2	2.1	2.1	1.7	1.7
Sudan	0.6	0.6	0.7	0.7	0.6	1.2	1.1
Tunisia	10.0	11.0	11.2	11.0	10.8	10.7	10.6
Uganda	9.5	9.2	8.7	8.4	6.4	6.5	6.4
Zambia	8.3	8.1	10.4	9.8	4.9	6.8	6.6
Zimbabwe	13.4	13.5	13.2	12.7	12.0	12.2	12.1

***Source**: African Development Bank database, 2023*

The quality of transport infrastructure can also be assessed using the Logistics Performance Index (LPI): "Quality of trade and transport-related infrastructure (1=low to 5=high)." Figure 2 shows that the score of the quality of trade transport related infrastructure was 2.50 in 2020 for COMESA Member States, except Egypt (3.0), Kenya (2.55), Mauritius (2.0), and Rwanda (2.90). Further analysis as shown in Figure 2 reveals that the quality level of trade transport related infrastructure improved across the region between 2010 and 2020, except for countries such as Burundi, Libya, Madagascar, and Uganda which experienced deterioration.

Figure 2: Quality of trade transport-related infrastructure (1=low to 5=high) – 2010-2020



***Source**: World Development Indicators. Note: Eswatini and Seychelles do not have data*

Analysis of the quality of roads, ports railroads, and airports is also essential. As shown in Table 4, COMESA region performs below the global averages on all the four selected transport infrastructure quality indicators. At continental level, COMESA Member States have better road quality and air transport infrastructure quality than other African counterparts. Countries like Egypt, Kenya, Mauritius and Rwanda were the best-performing economies in the COMESA region, with scores above world averages. Most of the countries in the region perform below the global average. However, the quality gap in the region is huge when viewing the ranks of the countries.

Table 4: Selected transport infrastructure quality indicators, 2019

Countries	Quality of Roads		Quality of Ports		Quality of Airports		Quality of Rail-roads	
	Score	Global rank	Score	Global rank	Score	Global rank	Score	Global rank
Burundi	3.9	75	3.2	104	3.8	107	-	-
DR Congo	2.1	136	2.4	124	2.8	136	1.9	93
Egypt	**5.1**	**29**	**4.8**	**38**	**5.1**	**43**	**3.8**	**45**
Ethiopia	3	116	2.8	119	3.3	129	3	66
Kenya	**4.1**	**64**	**4.2**	**66**	**5**	**48**	**4**	**37**
Madagascar	2	139	3.4	96	3.5	120	2	92
Malawi	2.8	123	2.2	128	3.3	130	2.1	88
Mauritius	**4.7**	**42**	**4.5**	**53**	**5**	**49**	**-**	**-**
Rwanda	**4.8**	**39**	**3.2**	**109**	**5**	**52**	**-**	**-**
Seychelles	4	71	4.4	60	4.4	86	-	-
Eswatini	4	73	3.4	97	3.8	109	-	-
Tunisia	3.6	97	3.4	98	3.6	117	3.2	59
Uganda	3.7	89	2.7	120	3.6	118	-	-
Zambia	3.4	105	2.7	121	4.1	100	2.1	91
Zimbabwe	2.8	124	3.1	114	3.5	122	1.9	95
COMESA	**3.6**	**-**	**3.4**	**-**	**4.0**	**-**	**2.6**	**-**
Africa	**2.7**	**-**	**3.4**	**-**	**3.9**	**-**	**3.4**	**-**
World	**4.1**	**-**	**4.0**	**-**	**4.6**	**-**	**3.6**	**-**

Source: *World Economic Forum. Global Competitiveness Index.* http://www.weforum.org/reports

Note: *1 represents the worst, while 7 is the best. Countries not shown have no data*

1.2 Problem Statement

Despite substantial liberalisation including implementation of COMESA Free Trade Area (FTA), intra-COMESA trade exports remain low, accounting for only 9.4 percent of COMESA's total exports in 2021. This is in contrast to intra-regional trade in the European Union (EU) (59.7 percent), Association of Southeast Asian Nations (ASEAN) (21.4 percent), Southern African Development Community (SADC) (10.6 percent) and East African Community (EAC) (21.8 percent) (UNCTAD Stats, 2023). As the largest regional economic community in Africa, COMESA has special potential to increase intra-regional trade in the framework of the recently signed African Continental Free Trade Area (AfCFTA). This will, in turn, increase economic growth and job creation throughout the region. These opportunities could be threatened by several factors including high non-tariff barriers, low levels of domestication of agreed policies, export similarities, low levels of uptake of digital tools and poor transport infrastructure.

Availability and quality transportation infrastructure are crucial for market linkages and trade growth while the lack thereof slows trade and disrupts markets. One of the principal obstacles to the trade growth in COMESA is the lack of suitable transportation infrastructure. Opportunities for trade growth are threatened by the limited routes' susceptibility to disruption and the prohibitive costs of carrying goods to market for local producers and dealers. Despite the existence of corridors, the region is still grappling with poor quality of roads and railroads. Lack of adequate transportation infrastructure is affecting both regional and international trade which are essential for attaining economic growth and boosting competitiveness.

These obstacles not only have an impact on domestic and international firms' productivity, but they also directly hinder the region's trade ambitions. Notwithstanding these obstacles, very few studies have examined how the quantity and quality of transport infrastructure affect intra-regional trade flows, especially in Africa, where regional blocs serve as a catalyst for the recently enacted AfCFTA. Furthermore, the primary criterion in this study is quality, whereas the majority of current studies evaluate the impact of transportation infrastructure primarily on quantity. Furthermore, from a COMESA perspective, there appears to be few research examining how common forms of transportation affect intra-regional commerce. Against this backdrop, the main research questions are: What is the relationship between transportation infrastructure and intra-COMESA trade? How does quality of road, railroad, ports, and airport infrastructure affect intra-COMESA trade?

1.3 Study Objectives

The study aims to empirically examine the effect of transport infrastructure quality on intra- COMESA trade. The specific objectives are:

i. To assess the effect of transport infrastructure development and quality on intra-COMESA trade; and
ii. To analyse the effect of quality of road, railroad, port, and airport infrastructure on intra-COMESA Trade.

2. Literature Review

This section provides theoretical and empirical literature review. Theoretical literature review centers on the theories that explain the role of transport infrastructure in international trade while empirical literature review focuses on the empirics on the nexus between the quality of transportation infrastructure and intra-regional or international trade.

2.1 Theoretical Literature

The traditional theories of international trade assume transportation costs and geographical considerations in determining trade. For instance, Ricardo's Comparative Advantage and Heckscher-Ohlin theories assume that goods are transported between countries without transportation costs, which barely justify the actual situation at a time when regional and global trade are heavily reliant on transportation infrastructure (Djankov et al., 2010).

Contrary to the traditional theories, the New Trade Theories (NTT) identify transport cost, network effects and returns to scale as key determinants of trade patterns. The new trade theories demonstrated that trade flows between nations can be determined by transportation costs and increasing returns to scale even in the absence of variations in productivity or factor endowments. Similar nations continue to have an incentive to trade with one another by lowering transportation costs and raising returns to scale. Certain industries in specific countries focus on particular specialised items in order to achieve economies of scale in those markets. Countries that specialise in different industries or specialised items then trade these products with one another. Through trade, the nations can take advantage of greater economies of scale.

The impact of both endogenous and exogenous transport costs has been examined using the NTT. The cost of transportation goods affects both profitability and the location of the industry. For instance, Tsubuku (2014) assessed the role of endogenous transportation cost in determining business location using new trade theory. According to the author, the larger nation has the capacity to generate more tax revenue for investments in public infrastructure than a smaller one, which lowers the cost of domestic transportation. Therefore, the effect on the home market is always greater.

The trade gravity theory is a component of the new trade theory since it highlights variables other than productivity and factor endowments that influence trade. The empirical study of international trade has made considerable use of gravity models since the work of Tinbergen (1962) and Pöyhonen (1963). They hypothesise that trade volume is inversely correlated with transportation costs and positively correlated with the economic size of trading partners. The impact of transportation infrastructure on global trade was estimated using the gravity model. For example, Bougheas et al. (1997) created a model in which public infrastructure and distance determine transportation costs. To capture the direct impact of transportation infrastructure, they incorporate a variable of public infrastructure. This study applied the gravity model with both distance and transport infrastructure to capture the direct effect of the latter on intra-COMESA trade flows.

2.2 Empirical Literature

Transportation infrastructure, which is mostly provided and maintained by the government, is a crucial part of global competitiveness (OECD, 2013). According to Hoekman and Nicita (2010) and Button and Yuan (2013), transportation is essential to the movement of products and can be impacted by inadequate infrastructure, which limits a country's capacity to integrate into the regional and global economy. A well-constructed transportation infrastructure reduces transit costs, improves the sites for economic activity, and enhances the production factors of capital and labour (Schwab, 2018). These arguments corroborate the findings of Portugal-Pérez and Wilson (2012), which revealed that the quality of transport infrastructure positively influenced exports in 101 nations, including developing countries.

High quality transportation infrastructure lowers transportation costs and increases accessibility. Shepherd (2016) affirms that by lowering transportation costs, a nation with an excellent transportation infrastructure promotes trade. According to Rehman, Noman, and Ding (2020), South Asian nations gain from transportation infrastructure, including roads, railroads, and airports, by boosting overall exports and lowering trade deficits while fostering regional economic ties. Zheng and Hongtao (2022) argued that international trade is improved by transportation infrastructure. The same sentiments were echoed by Jaworski et al. (2022) who demonstrated that USA highways had a major influence on both domestic and foreign trade flows. A groundbreaking empirical study by Limao and Venables (2001) employed the gravity model with bilateral trade data for 93 countries to evaluate the effects of infrastructure on bilateral trade. The authors found that improving infrastructure from the 75th to the 50th percentile boosts trade flows by 50 percent. The authors also point out that boosting African trade requires Sub-Saharan Africa's infrastructure to be improved.

Improved road infrastructure enables firms to reach both internal and external markets easily, lowers transportation costs, and gives consumers access to a wider range of items at affordable prices. Inland freight means are used to transport commodities to seaports and airports; the quality of these modes is important for timely deliveries, particularly for sensitive goods (Rodrigue and Notteboom, 2017). Beyond a country's socio-economic needs, roads are an essential means of transportation, particularly for those that rely heavily on trade agreements, like the COMESA Member States. Celbis, Nijkamp, and Poot (2014) note that poor quality roads may result in increased transportation costs due to increased fuel consumption and transit time. An empirical study by Cosar and Demir (2016) examined the effect of internal transportation infrastructure on Turkey's access to global markets using the gravity model. Their findings indicated that Turkey's exports increased and transportation costs decreased as a result of investing in its roads. This reduced transit times of moving goods from their point of origin to ports and airports on time. Another study by Kodongo and Ojah (2016) used system generalized methods of moments (GMM) to examine how road infrastructure affects growth and development in Sub-Saharan Africa. They proved that ongoing investments in road infrastructure and improvements in accessibility have an impact on Sub-Saharan Africa's economy.

The airport infrastructures differ between developing and developed nations (Button, 2008). Despite having a sizable number of airports, developing nations struggle with issues including poor quality, lack of commercial services, and shortage of personnel. Exporting time-sensitive goods and intermediate inputs that are traded inside manufacturing networks may be adversely impacted by these factors. Button, Doh, and Yuan, (2010) applied multiplier analysis to quantify the regional economic implications of an airport. They found that air transportation has grown in importance for both the carriage of goods and individuals. However, research analysing its effect on developing economies seems scarce. Another empirical study by Florida, Mellander, and Holgersson (2015) used a multiple regressions analysis to investigate the relationship between airport infrastructure and regional development. They found that airports had a positive impact on regional economic development, which is driven by the flow of people and goods. As airports grew in size, their scope became increasingly important. The airport facility is perfect for lowering travel costs in landlocked countries (Fink, 2002).

Maritime transportation is a crucial part of global trade and is usually utilized for restricted and high-volume goods that are either too expensive or too small to be transported by air (Suárez-Alemán, Morales, Serebrisky, and Trujillo, 2015). According to the United Nations Conference on Trade (UNCTAD, 2018), about 80 percent of international trade is carried out through marine ports. As a result, the effectiveness and quality of ports are critical to a country's or region's growth. With its various linkages and alternatives for trans-shipments, containerisation is at the forefront of market globalization (Rodrigue & Notteboom, 2017). An empirical study by Munim and Schramm (2018) used the structural equation model (SEM) to demonstrate how greater port infrastructure quality enhances logistics and maritime commerce. The study also demonstrated that port quality is a factor that distinguishes developed and developing nations and favourably affects trade in the former. Another study by Suárez-Alemán et al. (2015) demonstrated how port efficiency significantly impacted emerging regions by connectivity levels using both parametric and non-parametric techniques.

Railroads are seen to be an effective inland transportation method for moving heavy loads over long distances. Through economies of scale (Rodrigue & Notteboom, 2017), railway infrastructure provides easier access to the inputs, raw materials, and intermediary goods that businesses need (Aritua, 2019). Using the general equilibrium model, Donaldson (2018) discovered that railroads in India enhanced both regional and inter-regional trade while lowering trade costs and prices.

2.3 Overview of Literature

The classical and neoclassical trade theories assumed zero transportation costs while the new trade theory identifies transportations costs and increasing returns to scale as the key drivers of trade flows. In line with the new trade theory, it can be argued that differences in transport infrastructure quantity and quality could be the basis for comparative advantage thus, making transport infrastructure applicable in the context of comparative advantage theories though previously ignored. Empirical literature supports the new trade theory by establishing that infrastructure availability and quality play a crucial in promoting trade and market connectivity while the lack thereof retards trade and disrupts markets.

3. Methodology

3.1 Model Specification

The gravity model of trade was employed in this study (Tinbergen, 1962; Bergstrand, 1985). The gravity model provides an explanation for the positive correlation between the economic sizes (Gross Domestic Products) of the trading partners and their export flows. The model assumes that export flows increase with the sizes of trading partners' GDPs, and vice versa. On the other hand, export flows are negatively influenced by the distance between trading partners, thus, the longer the distance the lower the exports and vice versa. In order to assess the nexus between the dependent variable (exports) and independent factors, this study adopts an expanded version of the gravity model that includes new variables and dummy variables. The gravity model's basic specifications are as follows:

$$X_{ij} = G\left(\frac{GDP_i GDP_j}{Dist_{ij}}\right)\varepsilon_{ij} \qquad (1)$$

where exporter and importer countries are denoted by i and j, respectively; X_{ij} is represents exports from country *i* to *j*; GDP_i is the exporting country i's GDP; GDP_j is the importer country j's GDP, and $Dist_{ij}$ is the bilateral distance between exporter *i* and importer *j*.

The general linearised gravity model can be represented as:

$$X_{ij} = \beta_0 + \beta_1 GDP_i + \beta_2 GDP_j + \beta_3 Dist_{ij} + \varepsilon_{ij} \quad (2)$$

Theoretical underpinnings and empirics on gravity models show intersectional effects and endogeneity bias of trade and its component parts when aggregate trade is estimated. To address this problem, the study considers bilateral trade flows for the trading partners independently as exporting and importing countries. To address the bias brought by unobserved heterogeneity in the model for computations, the study used panel data analysis.

In line with empirical literature (Anderson, 2011; Duranton et al., 2013), the effect of transport infrastructure on intra-COMESA trade flows was examined using an enhanced version of the gravity model. However, because of the problem with zero trade values, the ordinary least square (OLS) model proposed by Anderson and Van Wincoop (2003) results in heteroscedasticity bias. Silva and Tenreyro (2006) suggested the Poisson Pseudo-Maximum Likelihood (PPML) model as the estimate method to deal with this econometric problem. They demonstrated that when estimating trade gravity models, the PPML model yields reliable findings. Moreover, the PPML model can generate objective and reliable estimates since it avoids autocorrelation, multicollinearity, and heteroskedasticity (Álvarez et al., 2018; Rahman et al., 2020). Taking into account the theoretical and empirical views, the study adopted the PPML model and the augmented gravity model is shown as follows:

$$X_{ijt} = \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP_{jt} + \beta_3 Dist_{ij} + \beta_4 Lang_{ij} + \beta_5 Cont_{ij} + \beta_6 Col_{ij} + \beta_7 Infra_{it} + \beta_8 Infra_{jt} + \eta_{ij} + \varepsilon_{ijt} \quad (3)$$

Where: X_{ijt} denotes intra-COMESA export of exporter country i to importer j at time t; GDP_{it} is exporter ***i's*** GDP; GDP_{jt} is the GDP of importer ***j's*** GDP***;*** $Dist_{ij}$ is the bilateral distance between country i and j; $Cont_{ij}$, $Lang_{ij}$, Col_{ij} and are dummy variables for contiguity and common official language and colonial ties, taking values 1 and zero otherwise. $Infra_{it}$ and $Infra_{jt}$ are vectors representing transport infrastructure variables for exporting and importing countries including composite indexes (***Transport Infrastructure Development Index, Quality of Transport Infrastructure Index and Quality of Trade Transport-Related Infrastructure)*** and four common modal freight variables including ***Quality of Roads, Quality of Ports, Quality of Railroads,*** and ***Quality of Airports***. n_{ij} represents country-pair fixed effects.

3.2 Estimation technique

In panel data analysis there are several estimation techniques used. The ordinary least square (OLS) technique was discarded because it produces biased parameters. The other options of panel data analysis are Random Effects (RE) and Fixed Effects (FE). The RE estimation is suitable for estimating trade flows between randomly selected samples of trading partners from a broad population, whereas the FE is best suited for estimating trade flows between ex ante predefined selections of countries.

The variables that do not vary over time are eliminated when the FE estimate technique is applied. As a result, the FE model works best when assessing the effects of factors that change over time. The FE estimate method is not the most appropriate because some gravity variables are non-varying. Heteroscedasticity issues are likely to affect the RE estimating method, causing less accurate parameter estimates. Therefore, the study employed the PPML because of its strength and capacity to address the limitations of the OLS, FE, and RE. Silva and Tenreyro (2006) argued that the PPML model consistently yields reliable findings when applied to trade gravity models.

3.3 Data Type and Sources

Panel data covering all 21 COMESA Member States from 2005 to 2022 was used in the study. Data on bilateral trade were gathered from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). The product-level detail data came from the United Nations COMTRADE database. Given that all of the sample countries are developing nations and that reporting errors may occur, the mirrored dataset is relevant in this instance. Since nominal trade flows are predicted by the theoretical model, the values are in current US dollars. This is justified because it avoids the so-called "bronze medal mistake" and there isn't an appropriate deflator for bilateral trade flows (Baldwin and Taglioni, 2007).

GDP data, which is expressed in US dollars were taken from the World Bank's World Development Indicators (WDI). CEPII provided the data for the gravity control variables including distance, colonial ties, common border/contiguity, and common official language. Country pairs with a common border, language, or colonial relationship are expected to trade more. Distance is expected to have a negative effect on trade flows.

To estimate the effect of the quality of transportation infrastructure on intra-COMESA trade, the study used both composite and freight modal variables that measure transport infrastructure quality as shown in Table 5. The three composite indexes of transport infrastructure variables were taken from different sources to guarantee the robustness of the findings *-Transport Infrastructure Development Index, Quality of Transport Infrastructure Index, and Quality of Trade Transport-Related Infrastructure.* The study also include distance to the nearest seaport to further investigate the role of seaports in intra-COMESA trade.

To capture the effect of the various modes of transportation on intra-COMESA trade, the study used disaggregated transport infrastructure quality indicators that corresponded to the quality of standard modal freight transport and the extension of asset indexes, such as Quality of Roads, Quality of Ports, Quality of Railroads, and Quality of Airports, derived from the World Economic Forum's (WEF) Global Competitiveness Report (GCR). As a result of reduced transportation costs and on-time delivery, a positive correlation between quality of the transport infrastructure and intra-COMESA trade is expected.

Table 5: Definitions of transport infrastructure variables and data sources

Variable	Measurements	Sources
Composite Indexes		
Transport Infrastructure Development	A composite index comprising: (i) total paved roads (km per 10 000 inhabitants) as proxy of access to paved road network; and (ii) total road network in km (total road network including both paved and non-paved roads)	African Development Bank
Quality of trade, transport-related infrastructure	Logistics performance index: Quality of trade and transport-related infrastructure (e.g. ports, railroads, roads, information technology), on a rating ranging from 1 (very low) to 5 (very high)	World Development Indicators
Transport Infrastructure Quality	Quality (condition and extensiveness) of roads, ports, airports and railroads on a scale from 1 (worst in the world) to 7 (among the best in the world)	World Economic Forum
Quality of standard modal freight transport		
Quality of Roads	Quality (condition and extensiveness) of roads on a scale from 1 (worst in the world) to 7 (among the best in the world)	World Economic Forum
Quality of Airports	Quality (condition and extensiveness) of airports on a scale from 1 (worst in the world) to 7 (among the best in the world)	World Economic Forum
Quality of Ports	Quality (condition and extensiveness) of ports on a scale from 1 (worst in the world) to 7 (among the best in the world)	World Economic Forum
Quality of Railroads	Quality (condition and extensiveness) of railroads on a scale from 1 (worst in the world) to 7 (among the best in the world)	World Economic Forum
Bilateral Maritime distance	Length of the existing shortest sea route between the two ports	CERDI-SeaDistance database
Distance to the nearest seaport	Length from the capital city to the nearest seaport	CERDI-SeaDistance database

4. Presentation and Discussion of Results

4.1 Descriptive Statistics

Table 6 displays the descriptive statistics for the variables. Statistical measures including mean, standard deviation, minimum, and maximum were used to describe the variables. As shown in the Table, between 2005 and 2022, the COMESA bloc exported commodities valued at US$ 33.8 billion on average and the average GDP was approximately $32.6 billion. Compared to destinations, this was $1 billion less. The average bilateral distance between trading partners was estimated to 2961.4 kilometers. However, in the regression analysis, we utilise the natural logarithm of GDP for origin, destination, and distance. On average, about 11 percent of trading partners have a common border (contiguity) whereas 56 percent shared a common language. About 33 percent of countries in our data have colonial ties. The average road distance to the nearest seaport from COMESA countries' capital city is 767 kilometers while bilateral marine distance between COMESA trading partners is 3,666 kilometers.

Table 6: Descriptive Statistics

	Obs.	Mean	Standard Deviation	Minimum	Maximum
Intra-COMESA Exports	5360	3.38E+07	1.15E+08	1	1.64E+09
GDP_Exporter	5860	3.26E+07	5.76E+07	380372.9	3.65E+08
GDP_Importer	5867	3.10E+07	5.66E+07	380372.9	3.65E+08
Distance	6800	2961.4	1639.0	176.0	8029.0
Contiguity	6800	0.11	0.31	0.00	1.00
Common Official Language	6800	0.56	0.50	0.00	1.00
Common Colony	6800	0.31	0.46	0.00	1.00
Transport Infrastructure Development	6800	15.02	16.92	0.55	56.51
Quality of Trade Transport Related Infrastructure	2520	2.21	0.38	1.35	3.21
Quality of Transport Infra-structure	1333	3.21	0.56	2.24	4.45
Quality of Airports	1146	4.06	0.83	2.44	5.60
Quality of Ports	1146	3.69	0.74	2.05	5.05
Quality of Roads	1146	3.69	0.74	2.17	5.11
Quality of Railroads	698	2.40	0.71	1.24	4.15
Distance to the nearest seaport	6800	766.57	628.49	0	1757
Bilateral Marine distance between partners	6800	3666.23	2715.13	0	10323

Source: *Author's own computations*

4.2 Baseline Regression Results

This study investigated the effect of transportation infrastructure quality on intra-COMESA trade. Table 7 shows the PPML estimation results of the augmented gravity model. The gravity model's control variables including GDP for exporter and importer countries, bilateral distance between COMESA trading partners, common official language and colonial links showed the expected signs

(Isard, 1954; Anderson, 2011; Baniya et al., 2020). Unexpectedly, the coefficient of contiguity (common border) showed a statistically insignificant negative sign across all models.

Table 7: PPML estimation results

	Transport Infrastructure Development	Quality of Transport Infrastructure	Quality of Trade Transport Related Infrastructure
Ln GDP Exporter	0.691*** (0.1582)	0.697*** (0.1534)	0.905*** (0.1382)
Ln GDP Importer	0.425*** (0.1018)	0.448*** (0.0866)	0.544*** (0.1236)
Ln Distance	-0.865*** (0.3712)	-0.980*** (0.3259)	-0.899*** (02767)
Common Official Language	0.805 (0.6110)	0.822 (0.4062)	0.411 (0.4787)
Contiguity	-0.534 (0.3150)	-0.645 (0.7253)	-0.493 (0.3950)
Colonial Links	0.685*** (0.2493)	0.657* (0.2413)	0.745*** (0.3256)
Transport Infrastructure Development-Exporter	0.270*** (0.0894)	-	-
Transport Infrastructure Development-Importer	0.167* (0.0762)	-	-
Quality of Transport Infrastructure- Exporter	-	0.745*** (0.2487)	-
Quality of Transport Infrastructure-Importer	-	0.262** (0.1864)	-
Quality of Trade Transport Related Infrastructure- Exporter	-	-	0.738*** (0.2750)
Quality of Trade Transport Related Infrastructure- Importer	-	-	0.466*** (0.2526)
Year-Fixed Effects	Yes	Yes	Yes
Country-pair Fixed Effects	Yes	Yes	Yes
Observations	5360	1333	1438

Note: Standard robust errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1%, respectively

The baseline gravity model results showed that both importer and exporter countries' market size (as measured by GDP) have positive and statistically significant coefficients. This indicates that greater market size translates into increased trade flows between the partners. Exporter country's GDP has a coefficient ranging from 0.691 to 0.905. This indicates that a 1 percent rise in GDP of exporting country will increase the value of trade by 0.691 to 0.905 percent. In addition, the importer country's GDP with coefficient ranging from 0.425 and 0.544, implies that a 1 percent increase in GDP of importing country will stimulate trade by 0.425 to 0.544. It can be concluded that the exporting country's GDP has a bigger influence on trade flows than the importing country's GDP. Because of the high demand and consumption in countries, higher GDP levels between trading partners lead to an increase in trade activities.

As expected, bilateral distance between trading partners shows a statistically significant negative coefficient ranging from 0.865 to 0.980. Thus, a 1 percent increase in the distance between trading partners will result in a 0.865–0.980 percent decrease in intra-COMESA trade flows. Trading partners' close proximity can lower transportation costs, which can improve intra-regional cooperation and trade. The coefficient of colonial link is positive and statistically significant at 1 percent level of significance, with coefficient ranging from 0.657 to 0.745. Sharing the same border (contiguity) and common official language have insignificant effect on intra-COMESA trade flows.

Regarding the variable of interest, transport infrastructure, the estimated coefficients for the three composite measures including ***Transport Infrastructure Development, Quality of Transport Infrastructure, and Quality of Trade Transport Related Infrastructure show expected positive signs. The coefficient of Transport Infrastructure Development*** shows a statistically significant positive effect on trade flows. Thus, a 1 percent increase in ***Transport Infrastructure Development*** could increase exports and imports by 0.270 and 0.167 respectively. This implies that increasing access to paved and non-paved roads plays a key role in enhancing exports and imports within the COMESA region. The findings are consistent with Portugal-Pérez and Wilson (2012) who demonstrated that the quality of transport infrastructure positively influenced exports.

The estimated coefficients of ***Quality of Transport Infrastructure*** are also significant at 5 percent level with values 0.745 for exports and 0.262 for imports. This showed that if the exporting or importing COMESA country increases its quality of transport infrastructure by 1 percent, its export value will increase by 0.745 percent while imports increase by 0.262 percent. In addition, the coefficients estimated for ***Quality of Trade Transport Related Infrastructure*** are positive and statistically significant with values 0.738 for exports and 0.466 for imports. Thus, a 1 percentage point increase in ***Quality of Trade Transport Related Infrastructure*** will increase exports and imports by 0.738 and 0.466 percent respectively. Consistent with Shepherd (2016), Rahman et al. (2020), and Zheng and Hangtao (2022), these findings establish that the quality level of trade transport related infrastructure (e.g. ports, roads, railroads and information technology) is critical in promoting intra-COMESA trade flows. The higher coefficients for exports provide evidence that exporting countries could benefit more from improving the quality of transport infrastructure.

4.2 Effects of Quality of Standard Modal Freight Transport on Intra-COMESA Trade

We also estimated Equation 3 using four common modal freight transport variables (***quality of roads, quality of railroads, quality of ports and quality of airports***), on intra-COMESA trade flows. This enabled us to determine the key mode of transport to focus on so as to enhance intra-regional trade flows. The estimated results for the four common freight modes are presented in Table 8. The gravity model variables: GDP for exporter and importer countries; the distances between COMESA trading partners; common official language; and colonial links, showed the expected signs (Anderson, 2011; Baniya et al., 2020). Contiguity or common border maintained a statistically insignificant negative coefficient.

The estimated coefficients for the transport infrastructure quality variables, including quality of roads, rail, ports, and airports show expected positive signs. The estimated coefficients for quality of roads positive and statistically significant for both exporters and importers. The coefficients showed that a 1 percent increase in the quality of roads could increase intra-COMESA exports and imports by 0.379 and 0.153 respectively. The findings support those of Cosar and Demir (2016) and Kodongo and Ojah (2016), who discovered that improvement in roads increased exports and decreased transportation costs, especially when moving commodities from their point of origin to ports and airports on time. According to Celbis, Nijkamp, and Poot (2014), roads are an essential form of transportation for nations that rely heavily on trade agreements, like the COMESA Member States.

The estimated coefficients also indicated that a 1 percent increase in quality of railroads, and ports could significantly boost both exports and imports by 0.582 and 0.306 percent respectively. These findings suggest high quality of railroads could promote intra-COMESA trade, that is, by providing easy access to raw materials, and intermediate goods which producers need. The findings corroborate the results of Donaldson (2018) who found that railroads in India reduced trade costs and increased inter-regional and regional trade.

The findings of the study also show a positive coefficient for quality of airports but statistically significant for exporters only. This result supports the findings by Florida, Mellander and Holgersson (2015) who found that airports positively affect regional development. Because air transportation is used to export high-value or time-sensitive goods, such as documents, pharmaceuticals, fashion clothing, production samples, consumer electronics, and perishable agricultural and seafood products, poor airport quality may have a negative impact on the processes of exporting of these goods as well as the exchange of intermediate inputs within production networks.

Table 8: PPML estimation results

	Quality of Roads	Quality of Railroads	Quality of Ports	Distance to nearest Seaport	Quality of Airports
Ln GDP Exporter	0.993***	0.792***	0.882***	0.835***	0.914***
	(0.1341)	(0.1332)	(0.1304)	(0.1431)	(0.1449)
Ln GDP Importer	0.607***	0.743***	0.548***	0.521***	0.547***
	(0.1174)	(0.1430)	(0.1149)	(0.1750)	(0.1187)
Ln Distance	-1.689***	-1.401***	-1.775***	-1.592***	-1.701***
	(0.2560)	(0.3441)	(0.2514)	(0.2572)	(0.2740)
Common Official Language	0.217	0.635	0.211	0.729	0.198
	(0.5002)	(0.5516)	(0.3746)	(0.5646)	(0.4568)
Contiguity	-0.214	-0.465	-0.237	-0.417	-0.228
	(0.4047)	(0.5131)	(0.4109)	(0.4739)	(0.4310)

Colonial Links	0.692*** (0.3454)	0.825*** (0.5003)	0.456** (0.3392)	1.201*** (0.4978)	0.678** (0.3355)
Quality of Roads Exporter	0.379*** (0.1322)	-	-	-	-
Quality of Roads Importer	0.153* (0.1985)	-	-	-	-
Quality of Railroads Exporter	-	0.582** (0.1745)	-	-	-
Quality of Railroads Importer	-	0.306** (0.1297)	-	-	-
Quality of Ports Exporter	-	-	0.488*** (0.1735)	-	-
Quality of Ports Importer	-	-	0.328*** (0.0794)	-	-
Bilateral Marine Distance between COMESA trading partners				-0.282** (0.1401)	
Distance to the Nearest Seaport- Exporter	-	-	-	-0.199* (0.1296)	-
Distance to the Nearest Seaport- Importer	-	-	-	-0.136** (0.0850)	-
Quality of Airports Exporter	-	-	-	-	0.256** (0.1442)
Quality of Airports Importer	-	-	-	-	0.157 (0.1393)
Year-Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country-pair Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	1146	698	1146	1146	1146

*Note: Standard robust errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1%, respectively.*

The coefficient estimate for quality of seaports is positive and statistically significant for both exporters and importers. The coefficients showed that a 1 percent increase in the quality of seaports could increase intra-COMESA exports and imports by 0.488 and 0.328 respectively. The findings suggest that seaports are a vital part of the supply chain in COMESA with each port having a far-reaching hinterland often spanning a number of countries. However, it is crucial to note that ports are often fed by inland corridors that have their own transport infrastructure, delay and cost issues, particularly countries that have no direct access to the sea. These findings corroborate the results by Munim and Schramm (2018) who found that port quality positively influences trade in the developing countries. To further investigate the role of marine transport in intra-COMESA trade, the study included bilateral marine distance between COMESA trading partners and distance to the nearest seaport. The coefficient estimate for bilateral marine distance is negative (-0.282) and statistically significant, suggesting that longer bilateral marine distance between COMESA Member States is negatively affecting intra-COMESA trade flows. This is further supported by the estimated coefficient for distance to the nearest seaport for both exporters (-0.199) and importers (-0.136) which is negative and statistically significant. The significance of marine transport supports the assertion by UNCTAD) (2018) and Humphreys (2023) that more than 80 percent of global merchandise trade (by volume) is transported via sea routes. Thus, reducing maritime distance between countries and distance from the capital city to the ports is crucial in increasing intra-COMESA trade.

Overall, the estimated results show that improving the quality of railroads and ports could provide greater opportunities to increase intra-COMESA trade. When compared to road transport, rail systems have higher capacity and can carry heavier loads over longer distances inland. In addition, rail generally has lower operating costs per ton kilometer than road transport. This is cost-effective for landlocked countries which transport goods for longer distance from the seaport. This affordability translates into lower prices for consumers and businesses and makes products more accessible and competitive in the marketplace. Thus, by choosing rail as their primary mode of transportation, COMESA Member States can improve their export capacity, attract foreign investment, and promote economic diversification. The significance for ports is unquestionable since they provide a gateway to COMESA trade. Ports have become a natural focus for regional and international development.

5. Conclusion and Policy Implications

5.1 Conclusion

The study employed the gravity model of trade, with the PPML estimation technique, with a panel of 21 Member States to analyse the effect of transport infrastructure on intra-COMESA trade flows during the period 2005 to 2022. The study established that availability of quality domestic transport infrastructure as well as trade-related transport infrastructure significantly promote intra-COMESA trade. For instance, quantitative analysis shows that a 10 percent increase in Transport Infrastructure Development, Quality of Transport Infrastructure, and Quality of Trade Transport Related Infrastructure induces a sizeable 2.70-percent, 7.45 percent and 7.38 percent increase in exports and a sizeable 1.67 percent, 2.62 percent and 4.66 percent increase in imports respectively.

A disaggregated analysis shows that access to quality road, rail, port, and airport infrastructure is crucial to intra-COMESA trade expansion. Empirical analysis shows that increasing the quality of roads, rail, ports and airports by 10 percentage points (pp) would increase intra-COMESA exports by 3.79 percent, 5.82 percent, 4.88 percent, and 2.56 percent respectively. The study also found that the maritime distance between COMESA trading partners has a significant negative effect on the value of imports and exports. The quality of transport infrastructure is a critical factor that has a positive effect on trade and can open the door to more trade by increasing the efficiency of the transfer and transportation of commodities. Based on the empirical findings, it can be concluded that as markets become more integrated, transportation infrastructure plays a crucial role.

5.2 Policy Implications

Based on the empirical results of the study, it is evident that the effect of transport infrastructure quality on intra-COMESA trade is significant, which makes it essential for countries to focus on the transportation sector. Thus, the following policy implications are suggested:

i. Member States should invest in both long-distance and metro-system railroads to increase connectivity to ports and internal markets, respectively. By investing in the development and expansion of rail networks, COMESA Member States can improve their logistics infrastructure, reduce transportation costs, and encourage cross-border movement of goods. This will foster greater trade cooperation and enable Member States to take full advantage of the AfCFTA and boost intra-COMESA trade. Moreover, investing in railway infrastructure could improve hinterland connectivity for landlocked countries and enhance their trade opportunities while reducing traffic congestion on the roads.
ii. To promote trade, COMESA Member States that lack adequate access to contemporary transportation options should invest more in ports and the transportation infrastructure that supports them. Governments might increase these investments to encourage more cooperation between nations in fostering effective local and international trade and in recognizing the importance of certain ports. Making ports more efficient also requires increasing capacity, lowering shipper delays, and enhancing port operations and management.
iii. COMESA Member States could also consider investing in road infrastructure to increase access to paved and non-paved roads. This will not only promote mobility and economic activity within the region but will also increase intra-COMESA trade.
iv. In addition to increasing the transport infrastructure services and facilities, it is imperative to focus on the improvement of the quality of the existing roads, railroads, ports and airports. All Member States except Egypt, Libya, Mauritius and Seychelles should invest more in road density, rail, and port facilities to facilitate intra-regional trade.
v. The COMESA Secretariat could also use the COMESA Infrastructure Fund (CIF) for development of railroads, ports and road infrastructure to support trade in the region.
vi. Improving hinterland connectivity through investment in road and rail infrastructure will enhance trade opportunities for landlocked countries in the COMESA region.

5.3 Areas for Further Research

This study has identified several areas where further research is warranted to continue expanding knowledge on the nexus between transport infrastructure and intra-regional trade. For example, there is need to further explore the linkage between transport infrastructure and trade flows in COMESA by recognising other issues such as border compliance and transport efficiency, trade efficiency and quality of economic institutions in these countries other than common language and colonial ties.

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