ESSAYS ON AGRICULTURAL PRODUCTIVITY, AGRICULTURAL TRADE OPENNESS AND THE EFFECTS OF AGRICULTURAL FINANCING ON AGRICULTURAL PRODUCTIVITY GROWTH: EVIDENCE FROM THE EAST AFRICAN COMMUNITY

JABUYA DANIEL OTIENO

X80/51001/2016

SUPERVISORS

1. Dr Fredrick Odhiambo Sule
2. Dr Jairo Ndwiga

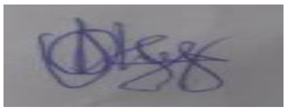
A PhD Thesis Submitted to the Department of Economics and Development Studies in Partial Fulfillment of the Requirement for the Award of the Degree of Doctor of Philosophy in Economics of the University of Nairobi.

September, 2024

DECLARATION

This PhD thesis is my original work and has never been presented for the award of a Degree in any other University.

Signed ……

 Date: 13th September, 2024

This thesis has been submitted with our approval as the university supervisors.

1. **Dr. FREDRICK ODHIAMBO SULE**

   Signed…. 

   Date… 13th September, 2024

2. **Dr. JAIRO NDWIGA**

   Signed…. 

   Date…. 13th September, 2024

DEDICATION

This thesis is dedicated to my late parents, James Jabuya and Mrs Penina Adoyo

ACKNOWLEDGEMENTS

The completion of the PhD journey would not have been possible were it not for the favour and blessings of the Almighty God, with whom all things are possible. I am highly grateful to my supervisors, Dr. Fredrick O. Sule and Dr. Jairo Ndwiga for their scholarly guidance and encouragement through this complex journey of writing my PhD thesis. Thank you very much for your constructive criticism, patience, advice, insightful comments and feedback that helped in improving the quality of this thesis. I am also thankful to Prof. Martine Oleche (chairman, Department of Economics and Development Studies), Prof. Anthony Wambugu, Prof. Richard Mulwa, Prof. Kamau Gathiaka, Dr. Owen Nyangoro and Dr. Simiyu Muricho for their invaluable comments.

I also express my deep appreciation to the University of Nairobi, Department of Economics and Development Studies for granting me an ooportunity to pursue my PhD studies. I benefitted a lot from the personnel and facilities. My special thanks to Departmental librarians, Jack and martin.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ACGS	Agricultural Credit Guarantee Scheme
ADB	African Development Bank
ADF	Augmented Dickey Fuller
API	Agricultural Productivity Index
ARDL	Autoregressive Distributed Lag
ASEAN	Association of South East Asian Nations
ATO	Agricultural Trade Openness
AU	African Union
CAADP	Comprehensive Africa's Agriculture Development Programme
CET	Common External Tariff
CFTA	Continental Free Trade Area
COMESA	Common Market for Eastern and Southern Africa
CPI	Crop Productivity Index
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DMU	Decision Making Units
DOLS	Dynamic Ordinary Least Squares
EACB	East African Currency Board
EAC	East African Community
ECA	Economic Commission of Africa
ECM	Error Correction Model
ECOWAS	Economic Community of West African States
ECT	Error Correction Term

EFFCH	Efficiency Change
EMCCA	Economic and Monetary Community of Central Africa
EU	European Union
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
FMOLS	Fully Modified Ordinary Least Squares
FSD	Financial Sector Development
GDP	Gross Domestic Product
GMM	General Method of Moments
IFPRI	International Food Policy Research Institute
LPI	Livestock Productivity Index
MRT	Marginal Rate of Technical substitution
NEPAD	New Partnership for African Development
NGOs	Non-Governmental Organizations
OECD	Organization for Economic Co-Operation and Development
OLS	Ordinary Least Squares
PSVCM	Panel Structural Vector Error Correction Model
RAIP	Rapid Agricultural Investment Plan
R&D	Research and Development
RTA	Regional Trade Agreements
REER	Real Effective Exchange Rate
SADC	Southern African Development Community
SDGs	Sustainable Development Goals
SFA	Stochastic Frontier Approach
SSA	Sub Saharan Africa

TC	Technical Change
TE	Technical Efficiency
TFP	Total Factor Productivity
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
USA	United States of America
VAR	Vector Auto-Regressive
VRS	Variable Returns to Scale
WDI	World Development Indicators
WTO	World Trade Organization

ABSTRACT

Countries in the East African Community are mainly agricultural economies with over 70% of their populations living in the rural areas. Trade amongst them is dominated by agricultural commodities. The importance of agriculture in the region makes it to be a significant contributor in the economy. To expand and sustain its productivity, trade and financing must play a critical role. This is a cross country study with countries being the units of analysis using panel data. The dataset is drawn from World Bank and FAO. Agricultural productivity trends are analyzed using DEA while determinants of agricultural productivity are analyzed using Tobit regression, truncated regression and double bootstrap approach. Effects of trade openness on agricultural productivity is examined using panel cointegration regression methods and bootstrap Granger causality approach. Effects of agricultural financing on agricultural productivity growth is analyzed using the CS-ARDL model and Panel Granger causality. Results indicate that agricultural TFP growth during the study period was 0.5%. TFP growth was mainly determined by technical change which grew at 0.9%. The low growth in productivity was due to negative growth in efficiency change. The agricultural sector in the EAC was also operating at a decreasing returns to scale. Analysis of exogenous determinants of agricultural productivity showed that institutional quality was the main determinant of productivity. Agricultural trade openness positively influenced agricultural productivity. Credit to agriculture and government agricultural sector development expenditure positively influenced agricultural productivity growth. Due to the significance of agriculture in the EAC, this study proposes a number of interventions. Strategies should be put in place to reverse negative growth in efficiency of the agricultural sector. Countries' policies that restrict trade or unnecessarily increase trade costs should be reviewed. The EAC governments should promote the strengthening of agricultural credit institutions to promote accessibility of affordable credit by stakeholders in the agricultural value chain. As recommended by the Malabo (2014) and Maputo (2003) declarations, EAC member countries should increase their agricultural sector expenditure. The quality and capacity of agricultural institutions should be enhanced to improve and maintain their significant contribution on productivity. The EAC governments should devise strategies to attract more members in order to expand the regional market.

OPERATIONAL DEFINITION OF TERMS

Crop Productivity Index (CPI)

It is the index of crop production for a particular year. It captures the total output of all crops with the exception of fodder crops.

Livestock Productivity Index (LPI)

This is the index of livestock production in a specific year. It captures the annual productivity indices of livestock and their products.

Agricultural Productivity Index (API): This is the ratio of indices for agricultural output to total inputs applied agricultural production. It measures the efficiency of inputs use in production.

Efficiency

The degree to which both use and allocation of resources yields the best possible output.

Productivity

The ratio of output to input used in production.

Technical efficiency

The extent to which inputs are used to produce outputs relative to the best practice

Trade Openness

This is the removal of barriers put in place to restrict international trade among nations that trade together.

Agricultural finance

These include public or private financial resources which are channeled to agriculture to enhance its productivity and development (Yazdani, 2008).

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Agriculture is the main economic activity for many countries whose economies are still developing. It has been established that approximately sixty-seven per cent of the whole globe depend on agriculture (FAO, 2021). According to FAO (2022), 37.1% of the East African Community GDP is generated from agriculture while agricultural exports constitute 43% of the total exports. Improved agricultural productivity has been cited as a powerful strategy towards the reduction of high poverty levels, boosting equitable development and provision of food security to the global population whose projection is 9.7 billion people by the year 2050 (United Nations, 2019).

Enhanced productivity in agriculture is estimated to be four times more effective in the improvement of income levels for rural populations in comparison to other sectors in an economy (World Bank, 2016) . The struggle to achieve higher long run growth will be most likely be influenced by agricultural sector performance. However, the level of contribution by agriculture to overall growth and development is still debatable among various development economists and stakeholders in the agricultural sector (Myrdal & Myint, 1984). Agriculture is crucial for economic growth. Approximately four per cent of world GDP is generated in agriculture and in some LDCs, the sector accounts for more than twenty-five per cent of the GDP (World Bank, 2022).

The economies of many countries in SSA and other underdeveloped countries are dominated by the agricultural sector. Among such countries, agriculture is important for growth, alleviation of poverty, creation of employment and improvements in income levels. To achieve these targets, many countries have devised strategies to increase and sustain productivity in agriculture (Oladije, 2006). As a result of its role and contribution in reducing poverty levels, analysis of trends in productivity levels in agriculture has drawn the attention of researchers in various underdeveloped economies. Agriculture is crucial in fostering the development and improvement of welfare in the EAC and other LDCs. Trade in agricultural commodities can transform livelihoods in predominantly agricultural economies. This is due to the creation of opportunities for farmers to export their commodities, earn incomes and increase the level of agricultural output. It also ensures availability of adequate food for households as a result of the effect on prices of commodities, and market accessibility by producers (Ouma, 2017).

1.1.1 Agricultural Productivity

Productivity is the generation of higher amounts of output quantities using a certain level of inputs in the production process (Shih- Hsun, Yu, & Ch'ing-C, 2003). Estimation of changes in productivity of firms and industries can be done using different methods. Growth in productivity across various sectors enhances growth, wealth and creates employment opportunities. High productivity makes firms to be viable and profitable. Therefore, it influences the level of competitiveness (Magati & Muthoni, 2012).

Trends or changes in agricultural productivity may explain the sources of agricultural growth in addition to constraints affecting productivity (Benin & Yu, 2013). Agriculture remains the dominant sector in SSA because of the crucial role it plays in poverty reduction and rural development. The need to increase and sustain its productivity explains why the sector is the focus of attention in SSA and other LDCs (Olajide, 2006). Addressing agricultural sector inefficiencies is necessary in order to increase efficiency and TFP growth (FAO, 2017; Sunge & Ngepah, 2020). Africa's challenge remains feeding a population growing faster than productivity growth of its agricultural sector (IFAD, 2012). The sector is dominated by small holder farmers who are the majority producers of crop and livestock products. Due to this background, it is necessary for the EAC region to engage in a more strategic and cooperative approaches towards the improvement of agricultural productivity (EAC, 2021).

Shortage of farm inputs and poor technology, few credit facilities and inadequate markets are among issues affecting the agricultural production in the EAC. This is further compounded by volatilities in food and energy prices. Agricultural sector investments have generally remained low and therefore have not been able to spur the growth and transformation of the sector. The agricultural sector in the EAC is further constrained by natural factors, policy and slow technology adoption. Such factors reduce the potential of the rural economy to reduce poverty levels by creating employment and generating income, meeting the increased food demand driven by urbanization and growth in population, conservation of natural resources and stimulation of overall economic growth. This is because agriculture has the largest capacity to promote rural growth and development (EAC, 2020). The EAC Regional Agricultural Investment Plan (RAIP) advocated for the acceleration of productivity by at least doubling agricultural output levels by 2025. The question as to whether productivity growth has been achieved can only be verified by measuring agricultural productivity trends in the region.

The EAC has also initiated various mechanisms aimed at improving agricultural productivity. Such mechanisms include improvement of extension services and post-harvest practices to reduce losses and wastage. Other measures include; increased surveillance, timely response to plant and animal diseases, application of better technologies in processing, storage and preservation and Promotion of strategies aimed at improving post-harvest handling and agricultural value addition.

1.1.2 Trade Openness

Openness is the removal of barriers put in place to restrict international trade among countries that trade together. Regional integration is viewed as a tool used by countries to enhance economic growth, industrial transformation and improvement of citizen welfare. The number of trade agreements among various trading partners globally has grown in the recent years. The WTO reported that there were over 350 RTAs in force (WTO, 2013). The gains from these agreements in promoting trade among various nations have resulted in many agreements being formed in SSA. The existing regional trade agreements in SSA include; SADC, ECOWAS, CEMAC, COMESA and EAC. RTAs liberalize trade through alteration of prices from partner states because tariffs on imported commodities from other countries are faced out leading to adjustments in demand patterns and trade flows (Ouma, 2017).

The quest for accelerated growth in developing and emerging economies has enhanced the reduction of trade barriers so as to facilitate the development of comparative advantages (Priyanka & Chakraborty, 2016). The Classical economists advocated for free trade on the basis that it promoted efficiency in resource allocation and disseminated knowledge and technology among countries (Umaru & Inusa, 2021). However, institutional imperfections in developing countries have created shortcomings in real life international markets (Ijirshar, 2019).

The EAC regional market offers member states opportunities to exploit economies of scale in production. This leads to specialization, economic efficiency and comparative advantage. Expansion of markets provides a means for attaining regional food security though optimal allocation of scarce resources according to prevailing regional opportunity costs. However, the agricultural markets in the EAC do not function optimally due to the unique nature of agricultural products, poor trade policies, market imperfections and poor state of infrastructure in the region (EAC, 2019).

However, agricultural trade openness in the EAC still faces a number of challenges. The challenges are attributed to inadequate and poor regional infrastructure, disparate legal/regulatory framework, national strategic priorities that are not aligned to regional priorities and divergent national attitudes and commitment to the integration project. In addressing challenges, the EAC has implemented reforms which include strengthening the capacity of partner states and improvement of access to markets. The EAC is also taking initiatives to link producers and other agribusinesses to markets through expansion of markets in secondary cities and towns. There is enhanced implementation of regional and multilateral agreements on technical barriers to trade and trade facilitation (Odjo et al., 2023).

1.1.3 Agricultural Financing

Agricultural finance includes all financial services towards production, processing and marketing of agricultural output. It comprises of short, medium and long term loans, leases, savings, service payments in addition to crop and livestock insurance (Dhrifi, 2014). There is a huge potential of transforming an economy by investing in agriculture (Diao & Dorosh, 2007).The agricultural sector in the EAC faces numerous challenges. The constraints include, high cost of agricultural inputs especially seed, fertilizers and machinery. Imperfect input markets, inadequate infrastructure, policy conflicts, high cost of borrowing, limited choice of improved seed varieties, animal and fish breeds also affect agricultural productivity (EAC (2018). There is need for adequate financial resources to address these challenges.

Though donor funding has an undesirable effect on recipient countries due to vulnerability as a result of external shocks, it continues to be a major source of finance for growth and development of agriculture in the EAC (EAC, 2019). However, promotion of policies that ensure efficient and prudent use of donor funding should be encouraged. This requires increased capacity and quality of institutions. FDI is an important component of financing in the agricultural value chains.

Domestic savings and investments are vital components of agricultural finance in the commercialization of agricultural production.

Between 2001 -2020, EAC countries on the average allocated 5% of their annual budgets to agriculture. From 2017-2022, development partners funded 90% of the sector's budget in the region. Upon the implementation of the Regional Agricultural Investment Plan (2018-2025), average government budgetary allocation to the sector by EAC countries is Rwanda (7.43%), Tanzania (6.14%), Uganda (5.89%), Burundi (5.63%) and Kenya (5.62%). In the 2022/2023 financial year, only 0.01% of the total EAC countries' budgets was allocated to agriculture (EAC, 2022). These statistics indicate that the agricultural sector in the EAC is faced by financing challenges.

1.1.4 The East African Community

The three EAC states; Kenya, Uganda and Tanzania have enjoyed various forms of economic interactions and relationships amongst them during the last century. During various transitions in economic integration amongst the countries, they shared a single monetary system called the East African Currency Board (EACB) for provision and regulation of currency. However, following the attainment of independence and subsequent establishment of independent central banks by the countries, the EACB ceased to operate. The EAC was then formed in 1967. It existed for 10 years before collapsing in 1977. The collapse was due to trade and industrial imbalances among the members. Protectionism and divergent political ideologies also contributed to its collapse (EAC , 2000).

As a regional body, the EAC is currently composed of six states. The membership of EAC includes Burundi, Rwanda, Kenya, Uganda, Tanzania, South Sudan and Democratic Republic of Congo (DRC). The headquarters of the organization are located in Arusha, Tanzania. Its work is guided by its own treaty which states the terms and conditions of the agreement. In November 1999, the agreement was signed and later operationalized in July, 2000 after the original three members (Kenya, Uganda and Tanzania) ratified it. Rwanda and Burundi joined the community in 2007 while South Sudan became a member in 2016 (EAC, 2017).

The EAC trade agreement was expected to facilitate increase in trade volumes and enhance higher growth rates among member countries. The degree of openness in a regional trade agreement is described by the increase in trade volumes and efficiency trade flow in commodities and services (World Bank, 2012). Agricultural output from the EAC countries like in many developing countries is facing various difficulties in accessing international markets because such markets are dominated by products from industrialized nations. Products from such countries are highly subsidized and have high standards and quality. However farmers in the less developed economies face many challenges and constraints which limit their capacity to practice large scale farming, use modern agricultural technology and produce high quality output (Ouma, 2017) .

Economic integration leads to spillovers in technological advancements, research, development and increased innovation which may positively contribute to growth of productivity in an economy. Integration expands the market for different commodities, leads to acquisition of additional knowledge and technology which contributes to innovation and economic growth (Krugman & Obstfeld, 1991).

1.1.5 Theories of Integration

Integration a joint initiative by countries to work together towards the achievement and advancement of their common goal. It allows member countries to perform certain functions that may be effectively carried out when they are performed jointly and not by individual countries. It enables the flow of trade between members, facilitates improvements in resource allocation by stimulating competition through expansion of the local market capacity. This has led the formation of many regional integration arrangements, several of which have a significant membership overlap in Africa.

Regional integration has been discovered to be important in promoting economic development. The main aim of integration initiatives is to address challenges faced in development. It involves the process where countries in a specific geographical region, collaborate and integrate their efforts in a particular functional or sectoral area such as trade, security and environmental protection. In Africa, the regional bodies include; Economic Community for West African States (ECOWAS), East African Community (EAC), Southern African Development Community (SADC), African Union (AU), Common Market for Eastern and Southern Africa (COMESA) and Economic and Monetary Community of Central Africa (CEMAC). Theories explaining the existence of such bodies include; Functionalism, Neo-Functionalism, Federalism, Realism, Pluralism and Intergovernmentalism. The theories have initiated debates on the organization of integration blocks to promote their efficiency and effectiveness (Adegun, 2013).

Functionalism theory explains that the principle of territorialism influences the building of structures of authority in states. The main focus of the theory was territory and authority. Its main proposal was the building of authority based on needs and functions which created linkages between authority and needs, expertise, technology and scientific knowledge. The theory was against political power and state influence. Within the framework of international integration, the theory ensures that there is collective governance and material interdependence between states. Each state has the freedom to develop its internal dynamics while integrating with other states in limited functional, technical and economic areas. The benefits arising from integration would win the support of their populations and promote their participation thus leading to expansion of the integration area. The main assumptions of the theory include; there is no sabotage by states on the process, the process of integration happens in a framework that permits human freedom and that there is existence of enough knowledge and expertise in achievement of integration goals.

The Neo-functionalism theory focused on the immediate process of integration. It involves the process where countries in a specific geographical region, collaborate and integrate their efforts in a particular functional or sectoral area such as trade, security and environmental protection. It described the invisible hand of integration as a spillover. There was functional spillover and economic spillover. Interconnection of various economic sectors, issue areas and integrating them into one policy area spilling over to others led to functional spillover. The creation of supranational governance models led to political spillover. The theory explained the process of regional integration based on empirical data. The proponents of the theory were in agreement with the functionalists that integration should begin with social, cultural, economic, trade and other aspects of commerce. To make integration successful, the theory proposed certain variables to be considered. The variables include; background condition of the integrating countries, the prevailing environment after integration arrangement and the general development as integration arrangements flourish. The main difference between functionalism and neo-functionalism is that the former focuses on global integration and the latter emphasizes on regional integration (Kehinde, 2014).

According to the realism theory, there are heavy expectations of development as a result of regional integration. However, the actual experience can be different. This is due to diversity in national interests, distribution of power and resources between and within states which can be very vast. The levels of trust are at times shaky due to inadequate formal and informal institutions which may promote efficiency of essential services like planning, contract enforcement, project preparations, conflict and dispute resolution. This creates a big gap between what is promised by formal regional institutions and the actual achievement by member countries. The policies, statements and protocols about regional integration are debated and agreed on at the formal regional institutions. On the other hand, it is at the national level where policy implementation is done. This may lead to variations in the achievements of individual countries who are members of a regional body.

The Intergovernmentalism theory treats national governments as the primary actors in the process of integration. It argues that national governments as state leaders, influenced by national interests determine the outcome of integration (Lombaerde & Van, 2007). In the EAC, the EAC Legislative Assembly, Council of Ministers and the EAC Court of Justice represent the supranational mode of decision making. The Pluralism theory advocates for peaceful co-existence of different interests and cultures. It brings about the respect for diversity. This makes people to direct their efforts towards the overall wellbeing of the whole community. Through collective effort despite the underlying differences, contribution to the common socio-political and economic development are made possible.

1.2 Statement of the Problem

Productivity is a vital component of growth and performance of an economy. Globally, various concerns have been raised about low and stagnation of agricultural productivity in many underdeveloped countries. The low levels of productivity are likely to affect food security for the rising populations. Improvement in productivity of the agricultural sector alleviates poverty and impacts on growth of an economy in various channels; it improves agricultural earnings among households and improves availability of food thus stabilizing prices. It also enables a country to save on foreign exchange that could have been used to import agricultural products and stimulation of demand for non- farm goods in rural areas which leads to creation of surplus in public and private investment. Improvements in agricultural productivity will ensure the sustainability of gains and growth induced by the agriculture.

Majority of EAC residents live in the rural areas where agriculture is the main economic activity. The low levels of agricultural productivity in the EAC is posing a serious threat to the general population due to over reliance on agriculture. The low returns from agriculture has led to continued migration of young and educated segments of the population to urban settings to look for employment opportunities. This will create shortages for agricultural labour and increase in urban populations. This may expose both rural and urban populations to food insecurity and aggravate levels of poverty. Unless productivity challenges in agriculture are addressed, the gains already made in poverty alleviation may not be sustained. The agricultural sector is facing mounting environmental challenges; including changing climate patterns, water shortages, treat – resistant plagues and increased incidences of natural disasters. Analysis of productivity trends and determinants is therefore crucial in designing strategies to improve productivity.

The expanded EAC market was expected to improve productivity in agriculture. This was expected to reduce rural poverty and enhance development. However, intra-regional exports have shown mixed results. In 2017, it accounted for an average of 19.2% of total exports which reflected steady decline from 26.06% achieved in 2012. Growth prospects for developing countries are mainly influenced by export oriented trade. However, the extent to which trade liberalization affects productivity remains unanswered. The intra-regional trade in the EAC from 2017 to 2021 accounted for 13.6% of the total trade.

Low agricultural output in SSA is attributed to slow growth of agricultural investments. Modern and large scale agriculture which is necessary in the achievement of economic growth requires use of modern agricultural technologies which further increases the financial needs of farmers. In the EAC, agricultural productivity is low due to small holder farming, lack of modern farming techniques, inadequate facilities for irrigation and limited adoption of modern technology in agricultural production. This therefore underscores the need for governments and financial institutions to undertake mobilization of adequate financial resources to be used in investment and development of agriculture.

1.3 Research Questions

The main research question of the thesis is: What is the influence of openness and financing on agricultural productivity in the EAC? The thesis seeks to answer the following questions;

(i) What is the trend and determinants of agricultural productivity in the EAC?

(ii) What is the effect of agricultural trade openness on agricultural productivity in the EAC?

(iii) What is the effect of agricultural financing on agricultural productivity growth in the EAC?

1.4 Research Objectives

The main objective is to analyze the influence of openness and financing on agricultural productivity in the EAC. The specific objectives are to:

(i) Measure and examine the trends and determinants of agricultural productivity in the EAC.

(ii) Analyze how agricultural trade openness affects agricultural productivity in the EAC.

(iii) Examine the effects of financing on agricultural productivity growth in the EAC.

1.5 Justification of the study

Agricultural growth and transformation is crucial in stimulating growth and development of underdeveloped economies. Agriculture is important in poverty eradication particularly among the LDCs. The sector increases real income by generating additional revenues (Christiaensen et al., 2006). It employs 70% of labour in less developed countries. Growth in productivity of agriculture may contribute to maximization of opportunities in both domestic and global markets. Agricultural production level must be sustained to improve food security for growing populations. Increased productivity in agriculture improves food security, reduces poverty levels and stimulates growth of various sectors in an economy. EAC growth has mainly been driven by agricultural production (EAC, 2018).

Agricultural investments directly influence the level of productivity in agriculture through a number of channels. Access to various sources of financial services facilitates the acquisition of funds for additional farm investments, improvement of post-harvest practices, enabling better accessibility to markets and development of better strategies to manage risks. The financial needs of farmers are different due to the amount of resources available to an individual farmer, the type of crops and livestock they specialize in, various links to markets, marketing strategies and other parameters that define the financial needs of farmers (Onoja, 2017). The beneficiaries of this study include governments, policy makers and stakeholders in agricultural production.

The choice of EAC of region was influenced by agriculture being the dominant sector in all EAC countries. Trade amongst EAC member states is dominated by agricultural products. It is therefore expected that growth in volumes of trade and adequate financing of the sector by EAC member countries would contribute to higher productivity levels in agriculture. The beneficiaries of this study include governments, policy makers and stakeholders in agricultural production.

1.6 Conceptual framework

The conceptual framework attempts to show the link among the three main components of the thesis: agricultural productivity, agricultural trade openness and agricultural financing**.**

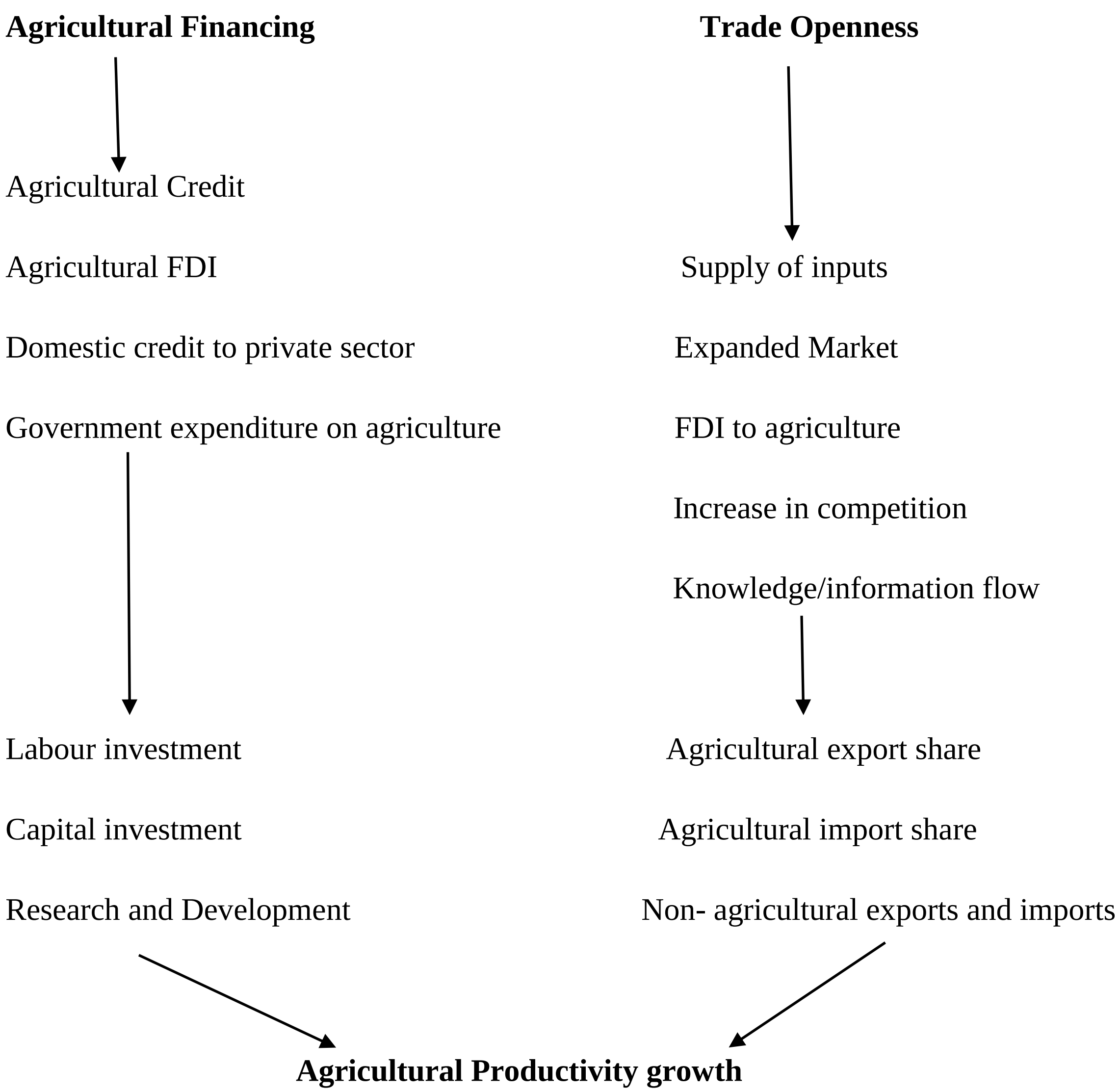


Figure 1.1: Conceptual Framework

According to Figure 1, both agricultural trade openness and agricultural financing affect agricultural productivity through various channels. Agricultural finance exists in the form agricultural credit, agricultural FDI, Official Direct Assistance (ODA), agricultural credit facilities and government budgetary allocations to agriculture. These channels of financing determine the availability of funds flowing into the agricultural sector for various investments. The funds then flow into the sector through capital investment, labour investment and agricultural R & D.

Capital investment involves the acquisition of inputs, equipment and other goods used in production of output. Investment on labour is money used for hiring of farm workers and payment of their salaries and wages. Research and development is the creation of new technologies, crop/livestock varieties aimed at improving agricultural production (Oluwafemi & Omenka, 2018).

The channels through which trade openness affects agricultural production include: supply of inputs; expanded markets; FDI channeled to agricultural production; increase in competition and knowledge (information) flow. These may influence changes in volumes of exports and imports in agriculture thus leading to productivity growth in the sector.

1.7 Scope and Organization of the Thesis

The thesis is designed to answer all the research questions. Each thesis objective is answered as an independent essay consisting of literature review, methodology, data analysis, discussion of results, summary and conclusions. In this kind of organization, the thesis aims to provide a clear framework on how the objectives will be achieved. The thesis has five chapters.

Chapter 1 provides the background information, discusses thematic areas and the problem statement. It also states the thesis research questions, objectives and explains the justification of the thesis and presents the conceptual framework.

Chapter 2 reviews literature on agricultural productivity, major methods of measuring productivity. It also reviews previous studies on agricultural productivity measurement. The chapter measures TFP in agricultural production. The chapter then provides an analysis of the factors determining variations in TFP values.

Chapter 3 reviews theoretical literature on the main theories in the evolution and development of trade. It also reviews relevant empirical literature on how trade openness affects productivity in agriculture. It then applies panel cointegration regression methods to analyze the effects openness on agricultural productivity. It also analyzes the causal relationship openness and agricultural productivity.

Chapter 4 discusses the various sources and models of agricultural financing. It reviews models explaining financial sector development, theories on how financing affects growth rates, empirical literature on agricultural financing and its effects on agricultural productivity growth. It examines the effect of financing on growth of productivity using the CS-ARDL model. Granger non-causality tests is used to test for causal relationships between variables.

Chapter 5 presents the thesis summary, conclusion, limitations and recommendations for future studies.

The study period for the thesis will be 1998-2022. Annual data for the five EAC countries used in the estimation of results. South Sudan and DRC were excluded in the analysis because they joined the community in 2016 and 2022 respectively. Their membership period in the EAC is not long enough to allow the assessment of how regional integration has affected their agricultural sector productivity and growth. The terms “EAC partner states”, “member states”, and “EAC countries” as used in this thesis will only apply to Kenya, Rwanda, Burundi, Tanzania and Uganda. The decision on the study period was mainly influenced by data availability and continuous EAC membership by the five members.

CHAPTER TWO

EMPIRICAL ANALYSIS OF TRENDS AND DETERMINANTS AGRICULTURAL PRODUCTIVITY IN THE EAST AFRICAN COMMUNITY

2.1 Background of the Study

In many developing countries, improvement in levels of productivity among various sectors has been a major priority in policy formulation and implementation. Due to the contribution by agriculture in national development framework of many countries, its level of productivity has attracted focus and attention more so in the LDCs. Agricultural productivity measurement is an area of interest among many researchers especially in the developing countries (Bedasa & Krishnamoorthy, 1997).

Many countries depend on agriculture because of its huge potential in contributing to economic growth, poverty eradication, increase in volumes of trade and economic diversification. High productivity due to advancements in technology and investments leads to higher agricultural incomes, employment and availability of food. This has shifted the attention of policy makers in exploring ways of enhancing agricultural productivity in SSA (Myeki et al, 2022).

Global and regional research has been focusing on agriculture in the recent past with the objective of improving growth in its productivity (Block, 1995). A lot of structural transformation has been witnessed in the agricultural sectors of various countries. Introduction of hybrid seeds, fertilizers, as well as institutions like co-operatives, marketing boards were all intended to improve its levels of productivity. Various policies have been formulated with a clear focus to upgrade production systems and increase commercialization of agriculture. However, heterogeneity among countries has led to different policy outcomes.

In 2012, approximately 870 million people globally could not satisfy their basic nutritional requirements due to inadequate food production. The increase in numbers of poor people and inadequate food for the populations are closely interrelated in SSA. The main determinant of food insecurity was identified to be low productivity growth in agriculture (World Bank, 2013). The demographic trends show that over fifty percent of the EAC population live in the rural areas (EAC, 2019). The continued land sub division and fragmentation due to increased population has contributed to food insecurity and vulnerability of various households to poverty (Fulginiti & Perrin, 1997).

Many African countries are still underdeveloped with agriculture being the dominant sector gauging by its contribution to GDP, employment, incomes, poverty alleviation and overall development. The growth of agriculture is therefore vital towards the achievement of overall growth targets. Many governments and their institutions have devised strategies and measures to improve agricultural productivity for them to achieve the above objectives (Olajide, 2006). Many farmers in SSA are unable to access modern agricultural technology, a factor which has affected productivity levels in agriculture. The main concern among agricultural policy makers is how to produce higher agricultural output using the current input level or produce the current output level using a reduced amount of the current input levels (Nkamleu, 2004).

A firm or an industry can expand its market share and increase the competitiveness of its products by improving its productivity. Globally there has been a concern about reduction and stagnation in the levels of agricultural productivity. This is common in developing countries where growth in productivity of agriculture is crucial in eradicating poverty. Fluctuation of productivity levels in agriculture affects the levels of overall development in the underdeveloped countries because agriculture is the largest sector in such economies (Pardey et al., 2007).

In the EAC, agriculture is the predominant source of livelihood. More than sixty percent of the population is employed in the agricultural sector. The agro-based based industries in the region account for over seventy per cent of all industries. Such industries use raw materials from the agricultural sector. More than half of the intra-regional trade is dominated by agricultural commodities (EAC, 2021). These statistics justify the critical role played by agriculture in the regional economy.

However, the agricultural sector has generally remained underdeveloped in terms of production for the domestic market and export. Various factors have contributed to the underdevelopment of the agricultural sector. Such factors include; poor infrastructure, low expenditures on R&D, low use of improved technologies and irrigation, inappropriate policies, weaknesses in capacities of agricultural institutions, poor access to inputs, negative environmental and climate change effects, low quality of the produce, low adoption of high yielding and pest resistant/tolerant varieties/breeds and poorly coordinated responses to emergencies and emerging issues. Price volatility in agricultural markets and fluctuations in production due to effects of climate change have affected the performance of the sector (EAC, 2021).

Many reforms have been implemented in the agricultural sector to improve its performance. The common objectives of these reforms include; doubling EAC agricultural productivity by 2025, improvement in productivity, increase in domestic production of basic goods, improvement in quality and standards of products and diversification of production and exports by promoting the development of new crop and livestock varieties and processing of primary products through value chain addition.

2.3 Problem Statement

EAC partner states have launched various initiatives to enhance productivity of agriculture. This has influenced the introduction of crop and livestock varieties with high yields, subsidized fertilizer prices, promotion of policies aimed at conserving soil/water and increased government expenditure allocation to the agricultural sector. However, despite these initiatives, yields of main crops in the region have either been declining or stagnated contrary to assumptions that such strategies are yield enhancing.

Despite its crucial role, agricultural production in the EAC region faces several challenges from which low levels of productivity is the most significant. Such challenges and constraints have led to low productivity of agriculture in the EAC in comparison to other regions globally. The constraints have affected the potential of the rural economy to eradicate poverty through creation of employment, generation of income, satisfying food requirements for the rapidly growing population and stimulating overall growth. The Malabo Declaration (2014) in which EAC member states are signatories recommended the doubling of agricultural production by 2025. Analysis of productivity levels may help explain whether there has been productivity growth in agriculture.

There is an urgent need to analyze agricultural productivity trends and determinants in the EAC. This will assist in designing strategies geared towards the improvement of growth in the regional agricultural productivity. Without such analysis, identification of various policy options and actions focusing on the improvement of productivity in agriculture may prove difficult. The region may in the future experience reversal of gains already made in poverty reduction, food security and economic growth if challenges facing agricultural productivity are not addressed in time.

2.4 Research Questions

The general research question of the study is: What are the trends and determinants of agricultural productivity in the EAC? The specific research questions are;

(i) What are the productivity trends of agricultural production in the EAC?

(ii) Has the formulation and adoption of EAC trade protocol translated to higher agricultural productivity among member countries?

(iii) Which factors determine productivity changes in agriculture?

2.5 Objectives of the Study

The main objective is to empirically analyze the trends and determinants of agricultural productivity in the EAC. The specific objectives are:

(i) To estimate changes in TFP and decompose TFP into its components.

(ii) To compare variations in productivity and assess how the EAC agreement has contributed to agricultural productivity.

(iii) To identify factors that determine productivity changes in agriculture within the EAC.

2.6 Justification of the Study

Many studies on agricultural productivity in the EAC have been on crop production in individual countries (Odhiambo et al., 2004; Ogada 2013; Kazungu 2015; Nkonya et al., 2004). None of the previous studies has disaggregated agricultural output into its main components (livestock and crop production) in analyzing trends of agricultural productivity particularly in the EAC. A review of studies on this subject shows that agricultural productivity analyses in the EAC have been partially done as most studies have either focused on single crops or a number of crops while leaving out the livestock sub sector. Such studies have been done in specific countries. However, cross country studies enable the comparison of agricultural productivity trends among groups of countries. The results of such studies may be useful to governments, policy makers and stakeholders in devising measures and strategies to improve agricultural productivity growth. Intense research in global and regional agricultural productivity changes has been motivated by the need to improve productivity in the sector.

The study attempts to investigate changes in cross - country levels of TFP, its components and an analysis of TFP changes in agriculture among members of EAC. The outcomes and recommendations of this study may prove useful in addressing productivity concerns in agriculture. Analysis of productivity trends may help explain whether there has been productivity growth in agriculture.

2.7 Literature Review

This section reviews literature on types of productivity and various methods of measuring productivity. It also provides empirical literature review on previous studies on productivity and their outcomes.

2.7.1 Theoretical Literature Review

Productivity is the ratio between outputs and inputs in the production process (Shi-Hsun, Yu, & Ching'-C, 2003). Emphasis on analysis of productivity in various studies is due to the recognition that high productivity influences the levels of growth. The level of productivity measures the response of output produced in relation to the variation of input levels during the process of production. Productivity analysis is a performance measurement tool for economic entities. Higher productivity is an indicator that resources are efficiently utilized. Both productivity and efficiency are used in measuring production performance (Mulwa et al., 2009).

2.7.1.1 Types of Productivity

Productivity may be described as Partial Factor Productivity (PFP) or Total Factor Productivity(TFP). PFP is productivity calculated as the ratio of total output to a single input. It indicates the variations in output attributed to a single production factor under the assumption that the contribution of other production factors have no effect on the output produced (Jayamaha & Mula, 2011). TFP is the productivity expressed as a ratio of total output to all inputs used. The accuracy and reliability of TFP is assumed to be more superior in the measurement of productivity levels (Alene, 2010).

2.7.1.2 Technical and Allocative efficiency

The ability of a firm to obtain the maximum achievable output using a given input set is called efficiency (Jayamaha & Mula, 2011). Economic efficiency is achieved when resource allocation leads to maximization of production and wastage is eliminated. Economic efficiency of an agent engaged in production comprises of two measures; technical efficiency and allocative efficiency (Farrel, 1957). The relationship that describes the physical response of output level changes to inputs level changes in the production process is known as technical efficiency. The use of correct set of inputs at the prevailing prices leads to allocative efficiency. Allocative efficiency is exhibited by a firm/industry if the price ratio of inputs equals Marginal Rate of Technical Substitution (MRTS) between input pairs.

Efficiency measures are categorized as either input oriented or output oriented. The output based measure attempts to explain that "by what margin can the output be increased using a set of inputs without any variation in the amount of inputs." The measurement of efficiency using the input oriented measure asks the question of how a reduction of inputs by a certain proportion can be done without changing the amount of output produced. In a constant return to scale (CRS) production technology, the two measures will coincide otherwise they will vary (Coelli et al, 2005).

2.7.1.3 Methods of Measuring Productivity

Frontier and non-frontier methods are the two main methods of measuring productivity. When there is no frontier specified and productivity is determined by a calculated value, it means we have non-frontier measurement of productivity. In frontier approaches, a production function is specified. Failure to specify a production function leads to non-parametric approach The decision on which method to adopt in productivity measurement is determined by the data available and the purpose of productivity measurement (Alene, 2010).

2.7.1.3.1 Non Frontier Approaches

Index number approaches involve the calculation a single index of productivity using all outputs and inputs. Laspeyres, Paasche, Fisher and Tornqvist indices are some of the common measurement methods for productivity using index numbers. The accuracy and reliability of the method has been challenged because they are not backed by any statistical principle and theory (Diewert, 1992). In Growth Accounting it is assumed that the production of output is done using labour and capital. The main indicators of growth in output are assumed to be capital and labour shares. Though it is preferred by some researchers because of its simple nature, it may generate inaccurate results due to exclusion of some inputs in productivity measurement (Caves, Christensen, & Diewert, 1982).

2.7.1.3.2 Frontier Approaches

In constructing a production frontier, it is assumed that firms are producing maximum output which implies that they are technically efficient. Before applying this approach in any estimation and discussing the significance of an efficiency measure, recognition of an efficient production function is necessary (Farrell, 1957). According to Farrell (1957), parametric and non-parametric methods may be applied in productivity measurement. The variation between the two methods is about their assumptions on how to treat the error term. The deterministic or non-parametric model makes an assumption that inefficiency stops firms from operating on the efficient frontier while the stochastic frontier or parametric method allows for the existence of statistical noise. The SFA method is used in the parametric approach because of the stochastic nature of the frontier. Due to the deterministic nature of the frontier in non-parametric approach, DEA method is used in the measurement of productivity.

Stochastic Frontier Approach (SFA)

The problem of averaging which is common in growth accounting is usually addressed using the SFA approach. The method has gained prominence due to its ability in identifying efficient values which are used to construct an efficient frontier. The strength of SFA is based on the ability to test for hypotheses by use of econometric techniques. The approach can account of maximum change in output change based on inputs. SFA being a base measure, makes efficiency measurement to be unaffected by all input or output levels remaining unchanged. The method assumes that technology and production function do not change across units of production and this is its major weakness. It imposition of restrictions on the production function and data distribution assumptions makes it vulnerable to mis-specification. The main criticism of SFA is its inability to be used in any estimation involving many inputs and outputs (Jayamaha & Mula, 2011).

Data Envelopment Analysis (DEA)

DEA is commonly used in measuring productivity because it does not impose restrictive assumptions on how economic agents behave or a production function can be specified. Depending on the objectives of a specific study, DEA can be described as input or output based. Estimation of DEA based on inputs enables the calculation of the maximum margin by which input changes does not affect the output produced. DEA estimation which is output based generates maximum output change without any adjustment in inputs (Fare et al., 1994). DEA uses linear programming in estimating Malmquist index using distance functions. It is popular because of its simple and direct way in the estimation of the TFP index. It breaks down the efficiency measure into its components in order to assess changes on productivity. The method is not affected by several assumptions like SFA and data used in its analysis is simple and not complicated to prepare. Unlike the Stochastic Frontier Approach used in productivity measurement, its application is not restricted by many assumptions. It does not make assumptions on behavioural objective as is common with various econometric approaches. The main strength of the DEA method is that it can accommodate more inputs and outputs (Coelli & Rao, 2005).

2.7.2 Empirical Literature Review

This section reviews various studies in which estimation of productivity levels and its determinants were the main areas of focus.

Odhiambo et al., (2004) assessed the determinants of productivity changes in agricultural production in Kenya from 1965 – 2001. Using the growth accounting approach, the study showed that productivity was mainly influenced by labour as it contributed 48% of the growth in agriculture. Fertility and land size also influenced the level of productivity. Climatic conditions, land size, fertility and the type of fiscal policy significantly enhanced productivity of agriculture.

Olajide (2006) applied DEA in examining productivity levels in the agricultural sector of SSA economies. DEA was used in the measurement and decomposition of TFP changes to estimate factors causing changes in productivity. The study assessed how quality of land, malaria prevalence, level of education and governance indicators affected productivity levels in agriculture. All variables in the study were confirmed to be significant except government effectiveness (law and order). Education level and the index of land quality revealed an inverse relationship with TFP indices in the region.

Tolga et al., (2009) assessed the productivity changes and its determinants in rice production in Marmara region of Turkey using input oriented DEA. An evaluation of efficiency determinants was done using the Tobit regression model. The results of the regression showed that the number of plots in a farm, age of an individual farmer and income from non-agricultural activities negatively affected technical efficiency changes while co- operative membership and size of individual farms positively contributed to efficiency changes.

Shabinejad & Akbari (2010) measured growth in agricultural productivity among eight less developed countries in Asia from 1993 to 2007. DEA was applied in estimating and decomposing TFP. The study revealed that TFP had significantly grown during the period. TFP decomposition indicated that growth in productivity was influenced by adoption of modern technology while technical inefficiencies led to low TFP growth. The adoption of modern farm technology made productivity growth to be influenced by technical change.

O'Donnell (2010) measured and decomposed agricultural productivity using DEA for 88 countries. The study found that only Nepal and Thailand had maximized total factor productivity during the period. Terms of trade variations on agricultural products had significantly affected TFP levels at various combinations of inputs and outputs. Technical progress within the sector had declined. The study recommended the adoption of modern technology in agriculture.

Yeboah et al., (2011) empirically analyzed the effect of NAFTA on productivity of agriculture among its members from 1980-2007. DEA was used in estimating and decomposing TFP for each member country. The TFP changes and its components in the agricultural productivity of each member country were compared between Pre-NAFTA and Post-NAFTA periods. The analysis showed that average productivity of agriculture grew by 1.6% for NAFTA countries. Growth was mainly attributed to technical change. TFP remained constant during the pre-NAFTA period but improved by 2.7% in the post NAFTA period.

Bao (2012) analyzed the factors affecting productivity of agriculture in Vietnam using both DEA and SFA for the period 1990 – 2006. There was TFP growth during the period while the shift in production possibility frontier showed that adoption of technology was the main determinant of growth in TFP. The low level of technical efficiency was attributed to managerial inefficiency. The characteristics of various regions, particularly the ratio of inputs showed gaps in the application of modern production technology. The conclusion was that the agricultural sector in Vietnam was more capital intensive.

Darku et al (2012) measured variations in growth of TFP in the Canadian agricultural from 1940 to 2009. Technical changes (TC), scale effects and technical efficiency changes were generated through TFP decomposition. Productivity growth within the crops sub sector was attributed to adoption of modern technology while livestock productivity was mainly influenced by scale efficiency effects. Technical progress was also significant in livestock productivity growth. The decomposition of TFP growth provided useful insights into the main contributions of research and development as well as government support towards productivity in agriculture.

Ogada (2013) analyzed factors that influenced the use of improved farm technologies and their effects on crop yields of small holder farms in Kenya. The used DEA in estimating technical efficiency. Tobit model was applied in evaluating the determinants of inter household variations in technical efficiency. The small holder farmers were technically inefficient by producing only 60% of the possible output. High levels of variations in technical efficiency among households was influenced by characteristics of various farmers, production environment and production risks.

Khan et al (2014) used non parametric approaches to estimate the TFP of the agricultural sector in Australia from 1991 – 2011. The average TFP growth rate of 0.59% in broad care agriculture was an indicator declining growth. The results further showed that absence of technical progress caused stagnation in productivity levels of agriculture. The study recommended the formulation of policies to stimulate investment and improve adoption of modern farm technology through agricultural research and development to spur productivity growth.

Nuno et al (2021) assessed the determinants of agricultural crop productivity among smallholder households in Harmaya District, Eastern Ethiopia. Analysis of relationships between variables was done using descriptive statistics and multiple linear regression models. Results showed that the length of farm experience by the household head, number of economically active members of the family, amount of organic fertilizer applied, irrigated land area and soil fertility status of farm land were significant determinants of agricultural crop productivity. The study recommended the provision organic fertilizer to farmers. Policies should also target adoption of improved technology and high seed quality to enhance agricultural production in Ethiopia.

Gaviglio et al (2021) estimated the productivity of farms in peri-urban areas within South Milan Agricultural Park in Italy. The study employed DEA approach that properly covered the heterogeneity of peri urban farm systems. Results showed that crop farms were more efficient than livestock farms, but they had less productive technology. The participation in short food supply chains and the multifunctional agriculture did not affect the levels of technical efficiency. Policies were needed to improve the educational levels of farmers and sustain the efficiency of farms.

HalsHwayo et al (2023) investigated the determinants of crop productivity and nutrition security in rural communities of South Africa. Using quantitative research method, the study found that most smallholder farmers did not have access to the irrigation system, mechanization and agricultural inputs. Irrigation systems and involvement in crop production positively influenced crop productivity of small holder farms. The study drew the conclusion that factors like irrigation systems and practicing of crop rotation influenced crop productivity. Government and non-government agencies should support farms with agricultural productive resources like irrigation systems and other inputs to improve crop productivity.

2.7.3 Overview of Literature

A review of theoretical literature discussed the types and measurement of productivity. Empirical literature review shows that DEA is widely used in measuring and comparing levels of productivity and performance among various production units. A decomposition of TFP is applied in the identification of factors determining changes in productivity levels.

Given that the output from crop and livestock productions are aggregated to form the overall agricultural output, the DEA method provides the most suitable approach in measuring and analyzing changes in agricultural productivity. There has been less application of DEA in measuring and evaluating the performance of productivity in agriculture within the EAC region. The livestock sub sector has not been incorporated in previous analyses of agricultural productivity in the EAC. All studies reviewed applied the two stage DEA estimation approach in productivity analysis. According to Simar & Wilson (2007), the method has significant weaknesses which should be accounted for. This study navigates this challenge by applying the truncated regression and double bootstrap estimation to analyze determinants of agricultural productivity.

This study enriches literature on EAC agricultural productivity by including livestock sub sector, climate change and institutional quality in productivity measurement because previous productivity studies did not consider the key role played by such variables. Many of those studies have either been on productivity of specific agricultural crops or a single component of agricultural productivity (technical efficiency) in specific countries and not for the region. Empirical analysis of agricultural productivity trends and determinants in the EAC is also a missing link in literature that this study aims to fill.

2.8 Methodology

2.8.1 Theoretical Framework

DEA is applied to estimate productivity changes in agriculture. The method allows the efficiency of a firm or industry to be estimated and compared with other firms/industries using distance functions. It is assumed that all firms and industries are operating below or on the frontier of efficiency (Farrel, 1957).

We assume that in every time period $t = 1, \dots, T$, the technology of production, T^t is applied to transform inputs, x^t, into outputs, y^t,

$$T^t = \{ (x^t,\ y^t) : x^t \ can\ produce\ y^t \ \} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ \ldots \ (2.1)$$

$$y^t \geq 0, x^t \geq 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots......(2.2)$$

The technology is assumed to have all feasible sets for vectors of inputs and outputs.

Distance functions are defined based on input or output. When the distance function is based on on inputs, we assume that output level is constant while output distance function assumes that the input level does not change. We define the distance function based on output as follows:

$$d_0\ ((x^t, y^t) = \min\{\varphi : (y^t/\varphi)\ \epsilon\ P(\ (x^t)\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (2.3)$$

d is the distance function, d_0 the output distance function, φ ratio of actual output production to optimal production of output (PPC output) and $(y^t/\varphi)\ \epsilon\ P(\ (x^t)$ indicates that possibilities in production are found in the output set (Bao, 2012).

2.8.2 Data Envelopment Analysis

In productivity measurement using DEA, there is no requirement for specification of a production function in any form. Charnes et al., (1978) developed the methodology by applying the concept of frontier concept initially developed by Farrell (1957). The model applied in this essay borrows concepts from Fare et al., (1994) on measurement of productivity. DEA is applied to generate Malmquist Productivity Indices for estimating changes in agricultural productivity among the EAC member countries. Countries are used units of analysis (DMUs).

In DEA analysis, the productivity measure for a firm or industry is determined by its location when compared to the efficient frontier. The weighted sum ratios of outputs and inputs are mathematically used to establish the efficient frontier. The efficient frontier or envelopment surface represents the highest possible achievement which a DMU can attain (Fare et al., 1994).

2.8.3 Malmquist Productivity Index and its Decomposition

Malmquist TFP indices are used in the examination of changes in productivity of agricultural production. By applying the approach of (Malmquist, 1953), the estimation of productivity scores in the agricultural sectors of EAC member states is done using distance functions based on outputs. In estimating productivity changes, this paper uses the methodology proposed by Fare et al., (1994). The output approach is applied in this study due to the assumption that farmers aim to minimize input costs and maximize the levels of output.

The estimation of MPI is done using output distance functions. They allow a production technology to be described such that it can accommodate additional inputs and outputs without specifying any behavioural objective. Such objectives include minimization of costs and maximization of profits. The input or output orientation of distance functions is determined by the objective of a particular study. If a constant return to scale (CRS) production technology is adopted in a study, both input and output oriented distance functions will yield similar values while under VRS technology of production, they will generate different values (Fare et al., 1994).

If technology in period t is taken to be the reference point during estimation, changes in the Malmquist TFP index between the two periods (s $(base\ period)$ & t) is described as:

$$m_0^t\left(y_s, x_s, y_{t,}\ x_t\right) = \frac{d_0^t\ (y_t, x_t)}{d_0^t(y_s, x_s)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (2.4)$$

If the reference technology is taken as period s, then the MPI index is defined as:

$$m_0^s(y_s, x_s, y_t, x_t) = \frac{d_0^s\ (y_t, x_t)}{d_0^s(y_s, x_s)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.5)$$

The above two productivity indicators which are based on the output produced will normally generate different indicators of productivity unless the technology of reference is Hicks output neutral.

As a precaution against choice of an arbitrary benchmark technology or imposition of benchmark technology as Hicks output neutral, specification of the Malmquist index is done by calculating the geometric mean of indices of productivity given by equations 2.4 and 2.5. The change in MPI output oriented value of the TFP index between the two period's *s* and *t* is then defined as;

$$m_0(x_t , y_t, x_s, y_s) = \left[\frac{d_0^s\ (y_t , x_t)}{d_0^s\ (y_s , x_s)} \times \frac{d_0^t\ (y_t , x_t)}{d_0^t\ (y_s , x_s)}\right]^{1/2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.6)}$$

In equation 2.6, $d_0^s\,(x_t , y_t)$ is the distance between period s and period t technology. y is the output level while x represents the input level. Malmquist Index is interpreted depending on the results of estimation: if $m > 1$ the implication is that there is TFP growth between period *s* and period t. If $m < 1$, indicates that there is a decline in TFP and when *m*=1, then the TFP is constant (Fare et al., 1994).

To show the determinants of productivity changes, the MPI is expressed in the following form;

$$m_0(x_t , y_t, x_s, y_s) = \frac{d_0^t\ (y_t , x_t)}{d_0^s\ (y_s , x_s)} \times \left[\frac{d_0^s\ (y_t , x_t)}{d_0^t\ (y_t , x_t)} \times \frac{d_0^s\ (y_s , x_s)}{d_0^t\ (y_s , x_s)}\right]^{1/2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.7)}$$

$m_0(x_t , y_t, x_s, y_s)$ is the output oriented Malmquist TFP index

$d_0^t\ (y_t , x_t)$ is the distance function value of output at period t with production technology at period t.

$d_0^s\ (y_t , x_t)$ Represents distance function value of output at period t with production technology at period s.

$d_0^s\ (y_s , x_s)$ Represents distance function value of output at period *s* with production technology at period s.

$d_0^t\ (y_s,\ x_s)$ Represents distance function value of output at period *s* with production technology at period t.

By expressing the Malmquist index in the format (equation 2.7), we derive two important components. The ratio $\frac{d_0^t\ (y_t, x_t)}{d_0^s\ (y_s, x_s\ )}$ is a measure of the variation in output due to TE between period *s* and period *t*.

The expression ($\left[\frac{d_0^s\ (y_t, x_t)}{d_0^t\ (y_t, x_t)} \times \frac{d_0^s\ (y_s, x_s)}{d_0^t\ (y_s, x_s)}\right]^{1/2}$) measures the adoption of new changes in technology which is expressed as a geometric mean representing the shift in technology of production between period *s* and period *t*. From the model, the efficiency change measures the degree of closeness by which a unit of production approaches the most efficient performance which is captured by the diffusion of technology or acquisition of relevant skill in the adoption of technology. The frontier effect (technical change) measures the change in position of the frontier between the two periods as a result of technology innovation and adoption (Fare et al., 1994). The two changes are independent of each other because a production unit may experience technical change without efficiency change or a firm may exhibit efficiency change without changes in technology. When the technical efficiency of a production unit is decomposed, we derive two new components; changes attributed to pure TE which explains changes in efficiency due to managerial improvements and changes as a result of scale efficiency which captures the optimality of the plant size.

2.8.4 Model Specification

DEA applies linear programming methodologies in constructing a non-parametric frontier within a dataset. According to Coelli et al., (2005), the constructed frontier is used to calculate efficiency values. To provide relevance to the objective of the study, EAC countries will be specified as DMUs.

In calculating the MPI for a specific DMU, the four distance functions in equation (2.7) are estimated to obtain productivity changes between period s and period t. Linear programming techniques are applied in solving the four distance functions in equation (2.7). The technical efficiency output oriented measure proposed by Farrell (1957) is taken as the reciprocal of output distance function (Fare et al., 1994).

Based on the relationship between TE values in DEA and the distance function, the study solved 4 distance functions in periods s and t: $d_0^t\ (y_s,\ x_s\ )$, $d_0^s\ (y_s\ , x_s\ )$, $d_0^s\ (y_t\ , x_t\ )$ and $d_0^t\ (y_t\ , x_t\ )$ using linear programming.

Problem 1: $d_0^t\ (y_s,\ x_s\ )$

$(d_0^t\ ((q_{k,s}, x_{k,s}))^{-1} = max\theta_{k,t}$ ……………………. ……………….. (2.8)

Subject to

$\theta_{k,t} q_m^{k,s}\ \leq\ \sum_{k=1}^{K} \rho_{k,t}\ q_m^{k,t}$ $m = 1, \ldots . . M$ ……………….. . (2.9)

$\sum_{k=1}^{K} \rho_{k,t} x_{k,t}\ \leq\ x_n^{k,s}$ $n = 1, \ldots . . , N$ ……………… .. (2.10)

$\rho_{k,t} \geq 0$ $k = 1, \ldots \ldots . K$ ……… ……….. (2.11)

An assumption is made that $k = 1, \ldots . . , K$ are countries utilizing $n = 1, \ldots N,$ inputs at time $t = 1, \ldots , T$. The n inputs are utilized in producing $m = 1, \ldots , M$ quantities of output.

The solution to problem 1 measures the technical efficiency value for the $\boldsymbol{i^{th}}$ country with the combination of production in period $\boldsymbol{s}\ (\boldsymbol{q_s}, \boldsymbol{x_s})$ using the technology of production in period t.

Problem 2: $d_0^s\ (y_s\ , x_s\ )$

$(d_0^s\ ((q_{k,s}, x_{k,s}))^{-1} = max\theta_{k,s}$ ………………………. ……………… . (2.12)

Subject to

$\theta_{k,s} q_m^{k,s}\ \leq\ \sum_{k=1}^{K} \rho_{k,s}\ q_m^{k,s} m = 1, \ldots . . M$ ……………….. ………. ……….. (2.13)

$\sum_{k=1}^{K} \rho_{k,s} x_{k,s}\ \leq\ x_n^{k,s}\ n = 1, \ldots . . , N$ ……………………………………. (2.14)

$\rho_{k,s} \geq 0 k = 1, \ldots \ldots . K$ ……………………………………. (2.15)

The solution to problem 2 measures the technical efficiency value for the i^{th} country with the combination of production in period $s(q_s, x_s)$ using the technology of production in period s.

Problem 3: $d_0^s\ (y_t\ , x_t\ )$ (2.16)

$(d_0^t\ ((q_{k,t}, x_{k,t}))^{-1} = max\theta_{k,t}$

Subject to

$\theta_{k,s} q_m^{k,t} \ \leq\ \sum_{k=1}^{K} \rho_{k,s}\ q_m^{k,t}$ $m = 1, \ldots .M$ …………………… (2.17)

$\sum_{k=1}^{K} \rho_{k,s} x_{k,s}\ \leq\ x_n^{k,t}$ $n = 1, \ldots ., N$ …………………… (2.18)

$\rho_{k,s} \geq 0$ $k = 1, \ldots \ldots K$ …………………... (2.19)

The solution to problem 3 measures the technical efficiency value for the i^{th} country with the combination of production in period $t(q_{t,} x_t)$ using the technology of production in period s.

Problem 4: $d_0^t\ (y_t\ , x_t\ )$ (2.20)

Subject to

$\theta_{k,t} q_m^{k,t} \ \leq\ \sum_{k=1}^{K} \rho_{k,t}\ q_m^{k,t}$ $m = 1, \ldots .M$ ………………….. (2.21)

$\sum_{k=1}^{K} \rho_{k,t} x_{k,t}\ \leq\ x_n^{k,t}$ $n = 1, \ldots ., N$ ………………… (2.22)

$\rho_{k,t} \geq 0$ $k = 1, \ldots \ldots K$ ………………… (2.23)

The solution to problem 4 measures the technical value for the i^{th} country with the combination of production in period $t(q_{t,} x_t)$ basing on technology of period t (Bao, 2012). Solutions will be generated for the four linear programming functions for each country to produce solutions for every DMU.

2.9 Estimation

In the **first stage estimation** productivity changes are estimated to generate TFP values. The TFP indices are decomposed into TE and TC. In equation (2.7), efficiency change between periods (*s* and *t)* is represented by the expression outside the bracket. The technical change due to adoption of technology between period s and period t is captured by the geometric mean of two expressions within the bracket. This shows that the multiplication of TE and TC gives rise to MPI (Fare et al., 1994).

The **second stage estimation** is aimed at assessing the sources and determinants of TFP. In this stage, we examine the exogenous factors influencing production efficiency scores generated in the first stage estimation. Since the efficiency values generated in first stage estimation range between 0 and 1, a model of censored regression (Tobit regression) will be the most suitable method for estimation of variables (Tolga et al., 2009). The Tobit model is defined as;

$$y_i^* = \beta_0 + \sum_{m=1}^{M} \beta_m x_{im} + \varepsilon_i \qquad \text{..........} \; (2.28)$$

Where

y_i^* is a latent variable representing the efficiency value

β_0 and β_m are the unknown parameters

x_{im} represents the independent variables

ε_i is the error term $N(0, \delta^2)$

2.10 Description and Measurement of Variables

*Crop Productivity Index (CPI)***:** Crop productivity index shows the crop productivity for a particular year compared to the base year. It captures the productivity of all crops with the exception of fodder crops.

Livestock Productivity Index (LPI): Like CPI, this shows the index of livestock productivity in a specific year in relation to the base year (period T). It captures the annual productivity indices of livestock and their products.

Gross Fixed Capital Formation in Agriculture (GFCFA): This is the total domestic expenditure allocated to the agricultural sector by the government of each EAC country. It is measured as a ratio of total government annual budget. The variable is expected to positively influence agricultural productivity.

Gross Capital Formation in Agriculture (GCFA): It is the gross domestic investment in agriculture. It consists of farm assets acquired to be used in agricultural production. It is expected to positively influence productivity in agriculture.

Agricultural Labour (AGR_LABOUR): This refers to total number of people working in the agricultural sector per year. Labour is used for performing various activities in farm production. Farm labour is expected to positively influence productivity in the sector. It is measured as a percentage of total employment in a country.

Arable land (ARABLE_LAND): It is defined as land used for planting and growing seasonal crops. It is measured as the size of arable land in hectares per person. The size land may positively or negatively affect productivity.

Fertilizer Consumption Rate (FERTL_CONS): This is measured in kilograms of fertilizer used per hectare of arable land. Proper use of fertilizers can positively increase productivity in agriculture.

Permanent Crop Land (PERM_CRPL): This is defined as such cultivable land that is not being used for annually harvested crops such as staple grains. It is a form of agricultural land that includes grasslands and shrubs used to grow grape vines of coffee, orchards used to grow fruits or olives and forested plantations used to grow nuts or rubber. It is further used for crop production and permanent pastures which include natural or artificial grasslands and shrubs used for grazing of livestock. It does not include tree farms intended to be used for wood or timber. This is measured as a percentage of total land area.

Malmquist Productivity Indices (MPI): These are productivity scores generated from first stage estimation. It measures the efficiency with which specific input amounts are applied in producing certain quantities of output in agricultural production.

Health: Agricultural work is energy consuming and requires healthy individuals to work in the farms. The average annual life expectancy in a country is used as a proxy for health. Life expectancy and is defined as a statistical measure of the average life time of a human being. High life expectancy is an indicator of good health and is expected to enhance agricultural productivity. Low life expectancy is an indicator of poor health which can negatively agricultural productivity.

Government Effectiveness: This indicates perception about quality of services offered to the public in addition to the nature and quality of policy formulation and implementation. Percentile rank is applied in measurement within a range of 0 to 100.

Control of Corruption: This describes views about the level state authority/power is exercised for private benefit. It includes petty and grand forms of corruption as well as capture of the state by elites. Percentile rank is applied in measurement within the range of 0 to 100.

Rural Population: This refers to the number of people living in rural areas expressed as a percentage of total population in a country.

Rainfall: This is the average amount of rainfall in millimeters recorded annually in a country. The amount of rainfall may negatively or positively affect agricultural productivity.

Climate Change: This is the variation in global or regional climate patterns. It is as a result of high levels of carbon dioxide produced by use of fossil fuels. It is measured as the amount of carbon dioxide emissions per year.

2.11 Sources of Data

Analysis is done using annual cross country data. Use of annual data is influenced by the fact that most data sets on agricultural productivity are annual data sets. Agricultural aspects like crop production are seasonal activities which makes it difficult to use monthly or quarterly data. The duration of the analysis period is influenced by data availability following the rolling out of EAC customs union in 2005. The choice of the study period also allows for a comparison between the pre-EAC period (closed trade) and post – EAC period (open trade). Data on Crop Productivity Indices (CPI) and Livestock Productivity Indices (LPI) will be accessed from FAO AGROSTAT data set. Data on arable land, fertilizer consumption, forest area, permanent cropland, climate change, rural population, capital, labour, total agricultural area, health, Institutional quality data (government effectiveness and corruption prevention) were sourced from the World Bank. Rainfall data was accessed from the World Bank Knowledge Portal. Malmquist Productivity Index (MPI) was accessed from the results of the first stage estimation.

2.12 Estimation and Discussion of results

2.12.1 First Stage Estimation

Table 2.1: Descriptive Statistics

The summarized statistics for variables is presented in Table 2.1.

Variable	Mean	Std. dev	CV	Variance	Skewness	Kurtosis
CPI	86.3657	23.8931	0.276650	570.880	-0.55653	2.67892
LPI	76.4221	21.3534	0.279413	455.970	-0.17306	1.88520
GFCFA	9.24632	3.9378	0.425877	15.506	1.83395	7.75359
AGR_LABOUR	73.6882	12.886	0.17490	166.070	-0.30844	2.22670
FERTL_CONS	10.0208	11.541	1.15170	133.202	1.28315	3.39106
ARABLE-LAND	26.8996	14.238	0.52930	202.741	-0.03770	1.43907
GCFA	19.7967	7.6076	0.38428	57.875	0.39103	3.25209
PERM CRPL	7.61035	5.324	0.69957	28.347	-0.16499	1.40572

Source: Author's computation

From Table 2.1, the mean of crop productivity index is 86.36%, while the index of livestock productivity is 76.42%. This is an indication that crop productivity is higher than livestock productivity in the EAC. Arable land is 26.89% of the total agricultural land while permanent cropland is just 7.61% of the total agricultural land. Agricultural labour constitutes 73.68% of the total labour. The coefficient of variation (CV) which is a ratio of standard deviation to the mean indicates that the variation between variables is not wide. The comparison between the mean and standard deviation, indicates whether the variables are significantly spread out from their means. The skewness statistic indicates that crop productivity index, livestock productivity index, agricultural labour and permanent cropland are skewed to the left. However, gross fixed capital formation in agriculture, fertilizer consumption and gross capital formation in agriculture are skewed to the right. This indicates that none of the variables has data distribution with perfect symmetry.

2.12.1.1 Summary of annual Means of MPI index

Table 2.2: MPI Summary of Annual Means

YEAR	TFPCH	CRS_TE	TECCH	VRS_TE	SCALE	RTS
1998	1.02996	0.9159428	1.05694	0.9832002	0.9303662	DRS
1999	1.01884	0.8865148	0.9598	0.9818322	0.9032214	DRS
2000	1.04958	0.894159	1.07854	0.9896312	0.9035568	DRS
2001	0.9794	0.9231428	0.9902	0.9857682	0.9353622	DRS
2002	0.90938	0.873846	0.92512	0.9673236	0.9006518	DRS
2003	1.0301	0.8345036	0.92458	0.9821086	0.8475152	DRS
2004	1.16144	0.8372118	1.19136	0.9645114	0.863594	DRS
2005	0.98364	0.8128396	1.09998	0.9789146	0.8278494	DRS
2006	0.9411	0.7731502	0.96334	0.9657062	0.7972404	DRS
2007	1.19014	0.8243866	1.10286	0.9754052	0.8406598	DRS
2008	0.97648	0.8284344	0.99702	0.9711512	0.8505128	DRS
2009	0.98722	0.77286	0.97914	0.9741648	0.7979546	DRS
2010	0.99128	0.726778	0.9659	0.9711302	0.747153	DRS
2011	0.94398	0.7816058	1.0214	0.9885434	0.7897856	DRS
2012	1.02714	0.7574356	1.03404	0.977621	0.7736288	DRS
2013	0.97332	0.7553762	0.94408	0.9926784	0.7607806	DRS
2014	0.97778	0.7992196	1.03878	0.9889548	0.8071676	DRS
2015	0.96154	0.764687	1.05056	0.963131	0.7901908	DRS
2016	1.02304	0.7940916	0.95872	0.9874948	0.8033524	DRS
2017	1.08642	0.831373	1.0201	0.9875528	0.840411	DRS
2018	1.07918	0.7953674	1.08488	0.9698544	0.7686738	DRS
2019	1.00784	0.7663036	1.04878	0.9642022	0.7925268	DRS
2020	1.02632	0.938715	0.9916	0.9838378	0.9524386	DRS
2021	0.9052	0.9594756	0.8535108	1	0.9594756	DRS
2022	0.87846	0.947023	0.8648904	0.9858378	0.9603102	DRS
MEAN	1.00555	0.831777	1.009928	0.979222	0.84577	DRS

Source: Author's computation

Table 2.2 presents a descriptive summary of average performance for the EAC during the study period (1998-2022). When the value of the MPI or any of its components is less than one, it is an indication of deterioration or drop in performance. MPI values greater than one are indicators of improved performance. A MPI value equal to one shows that there is no change in performance. Given that our main focus is the aggregate output, the output distance function is therefore treated as frontier production function since the frontier yields maximum feasible output from inputs used in production.

From Table 2.2, MPI components with the exception of total factor productivity and technical change recorded values less than 1 which was an indication of a negative growth in performance. The growth in TFP was less than one percent (0.5%). This was attributed due to TC rather than TE. This result agreed with the findings of Ajao (2006) in the empirical analysis of agricultural productivity in SSA. An average efficiency change of less than one indicates that all the EAC states were performing below the efficient frontier. The growth in efficiency change was negative 16.8% which affected productivity growth. The growth in technical change was 0.9% which contributed to the slight improvement in TFP performance. The results indicate that the DMUs were drifting away from the efficient frontier, thus affecting productivity. This may be due to absence of technology diffusion or failure to use the correct technology. The slight positive growth on technical change (frontier effect) can be attributed to technology adoption or innovation which was shifting the frontier upwards and thus contributing to growth in TFP.

By decomposing the efficiency change (CRS_TE) we got pure technical efficiency (VRS_TE) and Scale efficiency (SE) which are measures of managerial efficiency and plant size optimality respectively. The two values registered growth rates of -2.08% and -15.42%. This was an indicator that there are managerial inefficiencies in agricultural production and all the DMUs were operating below their optimal capacity. These results contributed to low growth in TFP. The agricultural sector of the region was operating at a decreasing returns to scale. This is an indication that output was increasing by a smaller proportion compared to increase in inputs.

2.12.1.2: MPI Summary of Country Means

Table 2.3: MPI Summary of Country Means

DMU	TFPCH	CRS_TE	TECCH	VRS_TE	SCALE	RTS
BURUNDI	1.0100448	0.8655158	0.998756	0.9997854	0.865687	DRS
KENYA	1.016996	0.7792510	1.002144	0.9536396	0.815482	DRS
RWANDA	1.0031	0.8966686	1.012332	0.9949496	0.900921	DRS
TANZANIA	0.984884	0.9155784	0.983992	0.9979001	0.917305	DRS
UGANDA	1.014296	0.7019023	1.004112	0.949836	0.738916	DRS
MEAN	1.00555	0.831777	1.009928	0.979222	0.84555	DRS

Source: Author's computation

The MPI index summary of country means (Table 2.3) showed that four countries registered positive growth in the TFP. However, the growth was by less than one percent. One country recorded a negative TFP growth. For technical change, three countries registered positive growth while two countries recorded negative growth. The other MPI components recorded negative growth rates. This confirms our inference from Table 2.2 that increase in TFP was mainly due to technical change. Four countries had their TFP values higher than the sample mean with Kenya recording highest growth followed by Uganda. Though all countries were operating below the efficient frontier, Tanzania was the most efficient. Rwanda recorded the highest growth in TECCH, Burundi in pure TE and Tanzania in Scale efficiency.

2.12.1.3 Comparison of MPI between Pre_EAC and Post_EAC

Table 2.4: Malmquist Index Comparison between Pre_ EAC and Post_EAC

PERIOD	TFPCH	CRS_TE	TECCH	VRS_TE	SCALE	RTS
.Pre_EAC	0.997483	0.893034	0.994229	0.9820877	0.9076674	DRS
Post_EAC	1.01189	0.783647	1.014971	0.9769707	0.7971455	DRS

Source: Author's computation

In Table, 2.4, an analysis of the region's MPI components between Pre_EAC and Post_EAC periods further confirm that the growth in TFP was due to TECCH**.** The negative growth in other MPI components was suppressing TFP growth.

2.12.1.4: A Comparison of MPI among countries between Pre_EAC and Post_EAC

Table 2.5: MPI Country Comparison between Pre_EAC and Post_EAC

MPI	Period	Burundi	Kenya	Rwanda	Tanzania	Uganda
TFPCH	Pre_EAC	1.0296181	1.011072	0.999736	0.953790	0.997754
	Post_EAC	0.995385	1.02165	1.005742	1.009314	1.027292
TECCH	Pre_EAC	0.992270	0.9916727	0.991136	0.955318	0.985090
	Post_EAC	1.0034485	1.0103714	1.0289857	1.006521	1.019057
CRS_TE	Pre_EAC	0.9013982	0.8827275	0.942551	0.987492	0.750991
	Post_EAC	0.837322	0.697948	0.860618	0.859074	0.663332
VRS_TE	Pre_EAC	0.999512	0.959837	0.998155	0.999135	0.953379
	Post_EAC	1	0.948770	0.992430	0.996929	0.946723
SCALE_EFF	Pre_EAC	0.901788	0.918672	0.944194	0.988334	0.785347
	Post_EAC	0.837322	0.734404	0.866921	0.861496	0.702435
RTS	Pre_EAC	DRS	DRS	DRS	DRS	DRS
	Post_EAC	DRS	DRS	DRS	DRS	DRS

Source: Author's computation

From Table 2.5, analysis of MPI components between Pre_EAC and Post_EAC periods, shows that all countries except Burundi recorded positive growth in total factor productivity (TFP) with Uganda having the highest TFP change in the sample at 2.7% on average per year. This growth was mainly due to technical change. All the five countries had a positive growth in technical change with Rwanda having the highest growth at 2.9%. This further shows that TECCH was the main factor influencing TFP change. In efficiency change, all countries recorded a negative growth, an indication that they were drifting further away from the efficient frontier with Kenya recording the largest drop of 18.47%. In Pure efficiency change (VRS_TE), Burundi recorded a 0.04% growth rate to reach the efficiency level, other countries in the sample recorded negative growth; Kenya (-1.1%), Rwanda (-0.5%), Tanzania (-0.2%) and Uganda (-0.6%). In Scale efficiency, all countries registered negative growth; Burundi (-6.4%), Kenya (-18.42%), Rwanda (-7.73%), Tanzania (-12.68%) and Uganda (-8.3%). This was an indication that the agricultural sector in all countries was operating below their optimal capacity. In both periods, all countries were operating under decreasing returns to scale production technology.

2.12.2 Second Stage DEA estimation

The most common method applied in analyzing the factors influencing productivity is the two limit Tobit regression. It is worth noting that, even though the method is commonly applied, it has two certain limitations. In applying the method, regression parameters generated by Tobit do not show a direct effect of the explanatory variables on the DEA scores (Ayoe, 2007). The two stage procedure is severely flawed thus rendering results generated and statistical inference based on such results to be unreliable (Simar & Wilson, 2007). This is because the DEA technical efficiency estimates may suffer from serial correlation. Furthermore, DEA lacks a clear process of data generation which compromises statistical inference. Therefore, d a bootstrap method based two-stage estimator which is statistically grounded was developed by Simar & Wilson (2007). The method eliminates these weaknesses by allowing for various options and testing of statistical significance of the outputs generated (Badunenko & Tauchmann, 2018).

We use DEA teradial analysis to generate efficiency scores (te_vrs_o). The estimates are also called radial measure of technical efficiency.

Table 2.6: Descriptive Statistics of variables

Variable	Mean	Std. dev	CV	Variance	Skewness	Kurtosis
EFFICIENCY	0.97922	0.03041	0.031055	0.000924	-1.27782	3.27775
HEALTH	55.8615	7.29751	0.130635	53.2536	-0.40870	3.11106
CORRUPTION CONTROL	27.1849	17.2608	0.634940	297.937	1.33713	4.23537
GOVERNMENT EFFICIENCY	29.1812	15.0207	0.514738	225.621	0.13386	2.473208
RURAL POPULATION	81.2671	6.45768	0.079462	41.7016	-0.21328	2.49372
RAINFALL	1066.727	233.4069	0.21880	544.78	-0.71183	2.61916
CLIMATE CHANGE	4392.22	4864.814	1.107597	2.3707	1.29742	3.98235

Table 2.6 presents summarized statistics for the variables. The mean of the efficiency index is 97.922%, an indication of negative growth in efficiency. The coefficient of variation (CV) which

is a ratio of standard deviation to the mean shows that there are no variables with wide variations across the EAC countries. The skewness statistic indicates that the index of efficiency, health, rural population and rainfall are skewed to the left. However, corruption control, government efficiency, and climate change are skewed to the right. This shows that there is no variable whose data distribution has perfect symmetry The average percentile rank for corruption control is 27.2% an indication that integrity issues are still a challenge. Government efficiency having a percentile rank of 29.2 shows that efficiency in policy formulation and implementation is still very low. This can contribute to low growth in productivity. Rural population comprises 81% of the total population indicates the importance agriculture in the region.

In this study, four empirical models are used to explain the determinants of inefficiency in agricultural productivity. We first run the Tobit and Truncated regression models to examine the determinants of inefficiency. Finally, we perform simarwilson algorithm (1) estimation (DEA single stage bootstrap estimation) and simarwilson algorithm (2) estimation (DEA double stage bootstrap estimation).

2.12.2.1 Estimation of Tobit Regression

Table 2.7: Tobit regression results

te_vrs_o	**Coefficient**	**Std. Error**	**p-value**
HEALTH	-1.102307	0.0008584	1.000
CORRUPTION_CONT	0.0014314	0.0004051	0.001
GOVT_EFF	0.0018378	0.0004514	0.000
RURAL_POP	-0.0001632	0.001294	0.900
RAINFALL	-0.08995706	0.0000256	0.726
CLIMATE_CHANGE	-0.8066507	1.95e-06	0.680
_Cons	1.005394	0.1305671	0.000
Var (e.te_v~0)	0.002166	0.0004214	
Prob > chi2 = 0.00000			
Number of Observations = 125 Uncensored = 63 Right Censored = 62 Left Censored = 0			

The Tobit regression results indicate that 62 observations have been right censored while 63 observations are uncensored. The effects of health, rainfall and climate change on the efficiency scores are insignificant. The effect of corruption control on efficiency scores is significant at 1%. This implies that a 1% variation in corruption control increases the total factor productivity by 0.0014 units. Government efficiency is also statistically significant at 1%. A 1% change in government efficiency increases efficiency scores by 0.0018 units. However, these results cannot be used to draw any inference since tobit results cannot be interpreted directly. In the last of analysis, we compute the marginal effects.

2.12.2.2: Estimation of Truncated Regression

In this estimation, the technical efficiency scores are truncated below one. This is an indication that the method excludes scores for efficiency value is equal to one.

Table 2.8: Truncated regression results

te_vrs_o	**Coefficient**	**Std. Error**	**p-value**
HEALTH	-0.0022075	0.0019925	0.268
CORRUPTION_CONT	0.0042143	0.0012084	0.000
GOVT_EFF	0.0025929	0.0010266	0.012
RURAL_POP	-0.0052514	0.0035303	0.137
RAINFALL	-0.0000251	0.0000328	0.443
CLIMATE_CHANGE	-1.713065	2.33e-06	0.461
_Cons	0.5315566	0.3583275	0.138
/sigma	0.0379437	0.006147	0.000
Prob > chi2 = 0.0288			
Number of observations = 63 Number of truncated observations = 62 Total observations =125			

Based on results presented in table 2.8, 62 observations were truncated leaving a total of 63 observations. According to the results of the truncated regression, the coefficients generated are very different in comparison to those of Tobit regression. However, signs of estimates is the same for the two methods. Corruption control and Government efficiency have statistically significant positive effects on the efficiency scores at 1% and 5% respectively. According to Simar & Wilson, (2007) and Badunenko & Tauchman (2018), incorrect estimation of standard errors may make some of the coefficients to turn to be negative. A 1% increase in corruption control, improves efficiency by 0.0042 units. On the other hand, a 1% increase government efficiency, increases efficiency by 0.0025 units. It is worth noting the coefficients of regression under truncated regression are larger than those of Tobit regression. This is because the two stage analysis involving tobit regression lacks a clear theory on the process of data generation. Therefore, the results achieved are affected by the finite sample bias (Simar & Wilson, 2007; Badunenko & Tauchmann, 2018).

2.12.2.3: Simarwilson Estimation

The estimation process involves implementing procedures for regression analysis of DEA efficiency estimates. The procedure involves simulating the unknown error correlation and calculating bootstrap standard errors and confidence intervals (Badunenko & Tauchmann, 2018).

2.12.2.4: Simarwilson Algorithm 1 Estimation

This is a single stage bootstrap procedure. It is run with a large number of bootstrap replications (2000) because we need to generate percentile confidence intervals for the coefficients.

Table 2.9: Simar & Wilson (2007) Efficiency Analysis (Algorithm 1)

inefficiency	Observed Coefficient	Bootstrap Std. Error	p-value
te_vrs_o			
HEALTH	-0.0022075	0.0019117	0.248
CORRUPTION_CONT	-0.0042143	0.0471811	0.000
GOVT_EFF	0.0025929	0.0951382	0.010
RURAL_POP	-0.0052514	0.032389	0.116
RAINFALL	-0.0000251	0.0546732	0.444
CLIMATE_CHANGE	-1.713065	0.2365063	0.461
_Cons	0.5315566	0.3379264	0.116
/sigma	0.0379437	0.0057357	0.000
Data Envelopment Analysis (externally estimated scores) inefficient if te_vrs_o > 1 Number of Bootstrap replications = 2000 Prob > Chi2 = 0.0187			

The coefficients of the estimates in this case are the same as those we got in truncated regression. This is because simarwilson algorithm (1) only influences standard errors and confidence intervals but leaves coefficients unchanged. In this estimation, corruption control and government efficiency remain the significant determinants of efficiency like in the other two estimations. A 1% increase in corruption control reduces inefficiency in agricultural production by 0.004 units. A similar adjustment on government effectiveness increases inefficiency by 0.002 units. This is a further confirmation that institutional quality is a critical determinant of agricultural productivity.

2.12.2.5: Simarwilson Algorithm (2) Estimation

This is a double stage bootstrap procedure. In this estimation, the efficiency scores which are corrected for bias are included model. This means that unlike in the previous estimations, externally generated scores are not allowed in this estimation. We therefore let simarwilson to perform its own internal bias correction. In addition to the 2000 bootstrap replications performed in simarwilson algorithm (1), we include 2000 bias corrected replications before we run the test.

Table 2.10: Simar & Wilson efficiency analysis (Algorithm 2)

inefficiency	Observed Coefficient	Bootstrap Std. Error	p-value
tebc_vrs_o			
HEALTH	-0.0021065	0.012145	0.234
CORRUPTION_CONT	-0.0037381	0.049532	0.031
GOVT_EFF	0.0026749	0.087238	0.012
RURAL_POP	-0.004251	0.033389	0.127
RAINFALL	-0.000516	0.053628	0.341
CLIMATE_CHANGE	-1.710206	0.233730	0.352
_Cons	1.018599	0.009866	0.000
/sigma	0.0355874	0.005017	0.000
Data Envelopment Analysis		No. of observations = 125	
Output oriented (Farrell)		No. of bootstrap reps = 2000	
Bias corrected efficiency measure		No. of reps (bc) = 2000	
Inefficient if tebc_vrs_o > 1		No. of efficient DMUs = 0	

Given that externally estimated scores are not used as dependent variables, we allow the test to run DEA internally. The output produced utilizes detailed information of the DEA model used. The use of bias corrected scores instead of the uncorrected ones, moderates the impact on estimated coefficients and confidence intervals (Badunenko & Tauchmann, 2018) . In agreement with algorithm one estimation, the significant determinants of inefficiency in this case are corruption control and government efficiency. A 1% variation in the control of corruption, reduces inefficiency by 0.0037 units. A 1% increase in government efficiency increases inefficiency in agricultural productivity by 0.0026 units. The regression coefficients under the double bootstrap procedure are larger than those of two stage DEA tobit regression. This is because the estimation procedure is based on a clear process of data generation. Therefore, the estimates of standard errors and confidence intervals are not affected by bias as a result of correlation in the estimated efficiency scores. The overall result of this estimation confirms the main result in stage 1 estimation that none of the DMUs in the analysis is efficient. Institutional quality variables are the main determinants of inefficiency in agricultural productivity. Given that institutional quality is determined by the government, the results of this analysis are in agreement with the findings of Schultz (1964).

Table 2.11: Descriptive statistics of bias corrected inefficiency

Summary of tebc_vrs-o

Variable	Obs	Mean	Std. dev.	Min	Max
Tebc_vrs_o	125	1.03181	0.250989	1.002813	1.117282

In table 2.11, sum tebc_vrs_o generates descriptive statistics for the estimated bias corrected inefficiency. When a comparison is done between the descriptive statistics of tebc_vrs-o and te_vrs_o, it is expected that correction of the bias should rule out seemingly efficient DMUs (Badunenko & Tauchmann, 2018). However, since simarwilson algorithm (2) estimation confirmed that none of the DMUs was efficient, none of the DMUs is ruled out. Therefore, the number of observations remain the same in both cases.

2.12.2.6: Estimation of Marginal Effects

To further estimate results of the second stage estimation, we interpret the mean marginal effects.

Table 2.12: Estimated mean marginal effects

Variable	**Tobit Estimation**	**Truncated Regression**	**Simarwilson Algorithm 1**	**Simarwilson Algorithm 2**
HEALTH	-0.01373 (0.217)	0.300612 (0.378)	0.300612 (0.3605)	0.311771 (0.3813)
CORRUPTION_CONT	-0.21767 (0.1681)	-0.222879 (0.0019)	-0.222879 (0.0012)	-0.22263 (0.0104)
GOVT_EFF	0.397294 (0.5247)	0.6601431 (0.00243)	0.6601431 (0.00184)	0.6601354 (0.00157)
RURAL_POP	0.043977 (0.6289)	0.053412 (0.21174)	0.053412 (0.21064)	0.04235 (0.4201)
RAINFALL	-0.67543 (0.12789)	0.880642 (0.31278)	0.880642 (0.30136)	0.66189 (0.4763)
CLIMATE_CHANGE	-1.94678 (0.7873)	0.96723 (0.4235)	0.96723 (0.4159)	0.87638 (0.5306)

Table 2.12 results indicate the health, rural population and rainfall have no effect on the efficiency estimates. However, the effects of institutional quality variables are significant. Both corruption control and government efficiency have significant effects on agricultural productivity. The marginal effects from Tobit estimation that are insignificant. This result agrees with Simar & Wilson (2007) that the DEA two stage analysis using Tobit generates incorrect estimates. In the case of corruption control, the estimated marginal effect shows that inefficiency in agricultural productivity is reduced by 0.222879 units when corruption control is increased by one unit. However, the estimated marginal effects on government efficiency show that a one percent variation in government efficiency makes inefficiency to increase by 0.6601431 units in agricultural productivity. The results provide evidence that government policy negatively impacts

on efficiency of agriculture. Government policies influence the level and stability of input and output prices. They also influence public investments that determine agricultural production, costs, revenues and allocation of resources. Such interventions if not well coordinated may lead to reduction in farm income and production below the expected levels. This can significantly affect the level of agricultural productivity. Corruption control has a significant negative effect on inefficiency. Corruption may burden farmers with costs. Small scale farmers may experience the effects of corruption in areas such as land titling and tenure, credit availability, quality of supplies, product standards and certification (like in the case of poor quality inputs) and marketing. Corruption impedes agribusiness involving issuance of permits and licenses. By devising strategies to control corruption, the government is able to improve efficiency of agricultural productivity.

2.13: Summary and Conclusions

The essay examined the trends and determinants of productivity of agriculture. Malmquist Productivity Index was estimated using DEA. The index was decomposed into its components. Total Factor Productivity grew by 0.5% while Technical Change (TECHCH) increased by 0.9%. Efficiency change (CRS_TE) grew by -16.8%, Pure change in efficiency (VRS_TE) grew by -2.07%, Scale Efficiency recorded a -15.4% growth. The was operating on a DRS technology. The results showed that growth in productivity was due to technical change. Efficiency change was negative, an indication that the countries were drifting away from the efficient frontier. Other components of MPI; VRS_TE (pure technical efficiency) and scale efficiency registered negative growth. The negative growth in pure TE (-2.07%) was an indication that managerial inefficiencies were contributing to low growth in productivity of agriculture. The negative growth in scale efficiency (-15.4%) indicated that the countries were not operating at optimal capacity in agricultural production. During the period, all the countries were operating at a decreasing returns to scale.

When the MPI for Pre_EAC and Post_EAC periods were compared, only TFPCH and TECCH confirmed recorded positive growth. Four countries achieved a positive growth in TFPCH. However, the growth rate was by less than one percent. All countries recorded positive growth in TECCH. In the second stage DEA analysis, the efficiency scores generated in DEA estimation were regressed against productivity determinants using Tobit regression. Due to limitations of the Tobit regression, truncated regression and simarwilson two stage bootstrap regressions were also used to verify the reliability of Tobit regression results. The tests confirmed that government efficiency and corruption control had a significant positive effects on the efficiency scores. The results of the second stage analysis were in agreement with the proposition of Schultz (1964). The institutional quality has significant effect on efficiency and productivity.

The estimation and analysis of marginal affects revealed two outcomes. The two stage analysis involving Tobit regression does not produce efficient estimates. This is due to weaknesses of Tobit estimation as explained by Simar & Wilson (2007). Institutional quality indicators (Corruption control and government efficiency) are significant determinants of agricultural productivity in the East African Community. While corruption control reduces the inefficiency, government efficiency increases inefficiency. This is an indication that agricultural sector policies need to be reviewed in order to address their negative effects on agricultural productivity.

2.14: Policy Implications

This study has revealed that lagging productivity in the EAC agricultural sector is due to negative progress in efficiency change, managerial inefficiencies and scale inefficiencies. All countries are operating on a decreasing returns to scale technology. Institutional quality is a major determinant of productivity and efficiency. There is need for development of governance instruments to strengthen the regional coordination of agricultural productivity. The capacity of training institutions and agricultural extension services should be strengthened and enhanced to impart farmers with adequate skills and knowledge to improve productivity. Agricultural research and development policies should be reviewed to address low productivity growth in agriculture. Measures should be instituted to improve the operational efficiency and effectiveness of institutions in the agricultural sector. There should be capacity building of farmers in order to improve their managerial skills. Strategies should be devised to enable farms to operate at optimal capacity. This may involve rotating crops and embracing diversity, integrating crops and livestock, adopting agroforestry practices, implementation of land reforms and adopting modern farm technology. The continued operation of the agricultural sector under decreasing returns to scale should be addressed. This may create serious challenges in the rural areas where agriculture is the main economic activity and source of livelihood. There should be enhanced adoption of high yielding and pest/drought resistant/tolerant varieties and breeds of crops and livestock.

2.15 Limitations of the study

The focus of the study was the East African region. The region has a membership of seven countries. However, the study period could not accommodate countries whose membership to the community is less than 15 years. Agricultural research and extension is a major determinant of agricultural productivity. However, there was no reliable data on the variable which led to its exclusion from the study. Due to challenges occasioned by climate change, over reliance on rain fed agriculture is posing a serious threat to agricultural production. Agricultural production using irrigation are some of the strategies that needs to be embraced to improve sector's resilience to adverse weather patterns. Complete data on agricultural areas under irrigation in all the EAC nations was not available.

2.16 Areas for Further Research

This study focused on the EAC even though SSA has several RTAs. Comparative studies could be done between the EAC and other regional blocks in the SSA. The EAC agricultural sector continues to operate under decreasing returns to scale. This can form a basis for future research. Agricultural production in the region is operating below its optimal capacity, a matter that needs investigation in order to recommend interventions for addressing the inefficiency.

CHAPTER THREE

AGRICULTURAL TRADE OPENNESS AND AGRICULTURAL PRODUCTIVITY:

A BOOTSTRAP PANEL CAUSALITY EVIDENCE FROM THE EAST AFRICAN COMMUNITY

3.1 Background of the study

Various economies have initiated measures aimed at opening up themselves for global trade. The liberalization of trade and financial sectors contributes to economic stabilization which leads to prosperity through interactions in the international markets. An assumption is made that openness in international trade promotes growth and stimulates development in the developed as well as underdeveloped countries. It enables countries to attract FDI, reduce trade balance problems and assists in the mobilization of local resources for employment creation and development (Salim & Najat, 2017).

International trade is believed to be a major determinant of growth which has impacted on the rapid development of many developed nations during the last century. Expansion of trade particularly the export sector creates additional demand which may lead to establishment as well as expansion of large scale industries. Removal of barriers to trade has become a powerful policy tool in the promotion of trade among the developed and undeveloped nations (Edwards, 1998).

Trade openness is the removal of barriers put in place to restrict international trade among countries that trade together. The process involves reducing or removing the amount of tariffs, abolishing or decreasing import quotas, streamlining the exchange rate system and reducing requirements for permits on imports. Expansion of markets and removal of restrictions caused by protectionism measures in the agricultural sector may make international trade to initiate competition among countries involved in agricultural production (Tahir & Khan, 2014).

Openness in trade results in import and export expansion of various agricultural commodities among countries that are trading partners. This has the potential to induce competition which may lead to improved earnings and high quality products. Inadequate competition may lead to production of low quality output with low market value (Umoru & Eboriem, 2013). Trade may enhance the rate of technological progress which could lead to productivity growth and expansion of markets (Dowrick & Golley, 2004). Openness enables the accessibility of large variety of capital goods by local producers which enlarges the productive knowledge base. Due to enhanced accessibility to additional knowledge and a variety of intermediate goods, an open economy is expected to achieve higher rates of productivity growth (Romer P. , 1990).

Agricultural trade is a source of livelihoods for farmers and those employed in the agricultural value chain. Globally, the trade reduces food insecurity and ensures the provision of a wide variety of agricultural commodities. Approximately twenty-four percent of agricultural export value is generated from imported inputs. Therefore, trade policies that create barriers to imports reduce the competitiveness of a country's agricultural exports through increased input costs (OECD, 2022).

Existence of long and cumbersome procedures alongside other frameworks aimed at regulating trade may increase transaction costs and result in low trade volumes. The facilitation of trade by relaxing trade restriction initiatives may be a powerful and useful instrument in addressing such problems thus resulting in a more conducive environment for intra-regional trade. Various regional agreements in Africa includes; COMESA, ECOWAS, CEMAC, EAC and SADC. The RTAs have initiated a number of measures aimed at enhancing cross border trade through automation of customs procedures. Many countries have also reduced the costs of doing business by initiating trade reforms (Onafowora & Owoye, 1998).

Most currently, many developing nations have been implementing policies aimed at enhancing trade openness. From previous studies, the experiences of many countries on reforms targeting trade policy indicate that growth in productivity of agriculture and improvements in domestic welfare mainly rely on the implementation of policies on trade reforms. The main aim for initiating frameworks for liberalization of trade was to increase the supply of wide variety goods to consumers; expand opportunities in agricultural production; increase competition in markets as well as attracting investments in agriculture. This was expected to improve productivity of output in the agricultural sector (Silva, Malaga, & Johnson, 2014).

3.2 Agricultural Trade and Trade Integration in the EAC

More than fifteen percent of the total economic activity in Africa is determined by agricultural activity (Odjo et al., 2023). The contribution of agriculture to GDP is higher in ECOWAS followed by EAC in comparison to TFTA, AMU and SADC. The volume agricultural trade is captured by proportion of total trade that is composed of intra-regional trade. The EAC being trade introverted with strong agricultural activity is an indicator that the sector is important in the economy. The region exports many products (tea, coffee, tobacco) like other African countries in addition to flowers. Like other RECs in Africa, it imports cereals, vegetable oils and sugar from within the continent and other continents. According to World Development Indicators (2023), 20-30 percent of the EAC GDP was generated in agriculture (World Bank, 2023). This is more than the four percent world share which is an indication that agriculture is an important sector in the EAC.

3.1.2 Competitiveness of EAC Agricultural Products

Table 3.1: Top 10 revealed comparative advantages (RCA) by each EAC country, 2019-2022 (average)

Country	Description	RCA
Burundi	Tea, black	12350
	Coffee, not roasted	4728
	Bran, sharps and other resid.	3149
	Coffee; husks and skin	2330
	Wheat or meslin flour	2112
	Coffee; decaff, not roasted	1108
	Cigars,cigarillos and cheroots	934
	Liqueurs and cordials	780
	Beverages, fermented	739
	Beer; made from malt	673
Kenya	Tea, black	15325
	Nuts, edible; macadamia	9791
	Flowers, cut; roses	9664
	Meat; of goats	7330

	Plants, live; unrooted	5549
	Veg., leguminous; beans	4994
	Vegetable prep; beans	4970
	Veg., leguminous; peas	3289
	Baking powders	2224
	Pineapples, prepared or preser	2029
Rwanda	Flour of sago or of root	60829
	Bran, sharps and other resid.	9634
	Tea, black	8685
	Coffee, husks and skin	6084
	Cereal flour; of maize	4880
	Juice; grape fruit	4548
	Yeasts;active	3747
	Resinoids	3600
	Wheat or meslin flour	2231
	Vegetables, leguminous; beans	2080
Tanzania	Pigeon peas	24498
	Cashew nuts in shell	12894
	Cloves neither crushed nor gr.	9087
	Oil-cake and other solid resid.	7263
	Sesamum seeds	6142
	Chickpeas	5441
	Flour, meal and powder	4536
	Hides and skins; raw	3651
	Millet	2821
	Waxes, other than vegetable	2813
Uganda	Plants, live; uprooted	10268
	Vanilla	6662
	Plants, live; roses	5155
	Coffee; not roast or decaff	3595

	Cotton; carded or combed	3210
	Cereal flour; of maize (corn)	3157
	Sesamum seeds	1931
	Germ of cereals	1872
	Pigeon peas	1760
	Dairy produce; milk and cream	1744

Source: Africa Agriculture Trade Monitor/ 2023 Report

Based on evidence presented in Table 3.1, the most cited product is coffee followed by tea. The value chain tea is very short while that of coffee is long and complex. However coffee processing is rarely done locally. EAC countries mainly export partially fermented and fermented tea and unprocessed coffee (Aboushady et al, 2022). The other feature of agricultural items exported by these countries is the low share of such items in the world market. Many items in the EAC countries have higher revealed comparative advantage have a world market share of low magnitude (Bouet and Sall, 2021).

Table 3.2: EAC Countries top 10 Agricultural Exports as a Share of Total Agricultural Exports

In the next table, we present the top ten agricultural exports for each EAC country and the share of total exports from agricultural exports.

Country	**Description**	**Share**
Burundi	Coffee, unprocessed	52.3%
	Tea, black	24.4%
	Wheat or meslin flour	5.8%
	Beer, made from malt	5.4%
	Cigarettes	5.1%
	Liqeurs and cordials	1.5%
	Avocados, fresh or dried	0.7%
	Beverages, fermented	0.6%
	Coffee; decaff	0.5%
	Bran, sharps & other resid.	0.4%
Kenya	Tea, black	30.3%

	Roses, flowers and buds	15.8%
	Coffee, unproc.	6.2%
	Avocados, fresh or dried	4.3%
	Beans shelled or unshelled	2.8%
	Cigarettes	2.6%
	Flowers for ornam, purposes	2.5%
	Nuts, edible; macadamia	2.1%
	Plants, live; unrooted	1.7%
	Palm oil	1.6%
Rwanda	Coffee; unproc	18.4%
	Tea, black	17.2%
	Palm oil	6.6%
	Wheat or meslin flour	6.1%
	Rice, semi or wholly milled	5.6%
	Flour, meal	5.1%
	Sucrose, chemically pure	3.5%
	Flour of sago, roots or tubers	3.5%
	Yeasts; active	3.1%
	Bran, sharps and other resid	2.1%
Tanzania	Cashew nuts	14.3%
	Tobacco stemmed	9.6%
	Sesamum seeds	9.0%
	Coffee, unproc.	7.8%
	Rice, semi or wholly milled	7.0%
	Pigeon peas	4.9%
	Chick peas	3.9%
	Maize (corn)	3.9%
	Cotton; unproc.	3.7%
	Soya beans	2.1%
Uganda	Coffee; unproc.	39.8%

	Cocoa beans; raw	6.1%
	Milk and cream	5.0%
	Sucrose, chemically poor	3.3%
	Plants, live; unrooted	3.1%
	Sesamum seeds	2.8%
	Cotton; unproc.	2.5%
	Roses, flower and buds	2.3%
	Tobacco, raw	2.2%
	Vanilla, unproc.	2.0%

Source: Africa Agriculture Trade Monitor/ 2023 Report

Table 3.2 presents the main agricultural exports and the share of total exports from agriculture. The table provides details of high concentration of various EAC countries' agricultural exports. The main export products for Burundi are black tea and coffee which constitute 76.7% of its exports. In Kenya, 36.5% of agricultural exports is composed of tea and coffee while in Rwanda the same products account for 35.6% of total agricultural exports. In Uganda, coffee represents approximately 40% of agricultural exports. In Kenya, the top four agricultural exports account for 56.6% of agricultural exports. These details indicate that EAC countries trade on a narrow range of agricultural products. The implication is that if such commodities experience volatility in the world prices, a country may suffer macroeconomic instability. It is therefore important for the countries to diversify their agricultural products.

Table 3.3: Top 10 agricultural imports of EAC countries as a share of total agricultural trade

Country	**Description**	**Share**
Burundi	Wheat and meslin	17.3%
	Sucrose, chemically pure	13.4%
	Husked (brown) rice	7.0%
	Cane sugar, raw	5.1%
	Food preparations, n.e.c	4.8%
	Malt; not roasted	3.3%
	Palm oil	3.2%

	Meat prep. Of bov. animals	2.7%
	Malt; roasted	2.6%
	Tobacco	2.4%
Kenya	Palm oil	25.0%
	Wheat and meslin	17.6%
	Rice, milled	8.8%
	Sucrose, chemically pure	4.9%
	Food preparations, n.e.c	2.7%
	Maize (corn)	2.6%
	Milk and cream	2.1%
	Vegetable oils; palm oil	2.1%
	Cane sugar, raw	2.1%
	Grain sorghum	1.4%
Rwanda	Palm oil	13.1%
	Sucrose, chemically pure	11.9%
	Rice milled	9.7%
	Wheat and meslin	9.0%
	Vegetable fats and oils	3.3%
	Cane sugar, raw	3.1%
	Malt, not roasted	2.9%
	Maize (corn)	2.3%
	Tomato sauces	2.2%
	Sunflower seed	2.1%
Tanzania	Palm oil	25.8%
	Wheat and meslin	19.4%
	Sucrose, chemically pure, n.e.c	8.1%
	Rice, semi or wholly milled	5.5%
	Cane sugar, raw	2.5%
	Food preparations, n.e.c	2.3%
	Oil-cake from soya-bean	1.8%

	Malt; not roasted	1.7%
	Maize (corn)	1.5%
	Sucrose, chemically pure	1.2%
Uganda	Palm oil	19.6%
	Wheat and meslin	15.8%
	Cereals; rice, milled	11.5%
	Sucrose, chemically pure	4.7%
	Vegetable oils; palm oil	4.3%
	Food preparations, n.e.c	2.0%
	Sugar confectionary	2.0%
	Yeasts; active	2.0%
	Margarine	1.9%
	Sauces and prep	1.8%

Source: Africa Agriculture Trade Monitor/ 2023 Report

Table 3.3 presents a list of agricultural commodities which are imported by EAC countries in large quantities. The imported items are dominated by cereals (wheat, maize, rice) and calories (sugar and vegetable oils). More than fifty percent of total agricultural imports in Kenya, Uganda and Tanzania are represented by palm oil and wheat. Since these countries have the capacity to produce these products locally, it is necessary to invest and build capacity in the production of such crops. Over reliance on basic food imports may expose EAC countries to food insecurity due to volatility of food prices in the world market.

Table 3.4: Top destinations of agricultural exports and origins of agricultural imports by EAC countries as a share of total agricultural trade

Destinations of Agricultural Exports			**Origins of Agricultural Imports**		
Country	Destination	Share	Country	Exporter	Share
Burundi	DRC	11.3%	Burundi	Uganda	
	Pakistan	11.2%		Tanzania	
	Germany	10.8%		Kenya	
	Uganda	8.1%		Zambia	
	US	5.9%		Belgium	

	Oman	5.6%		Russian Fed.	
	Sudan	5.3%		China	
	Belgium	4.1%		Malawi	
	China	4.0%		UK	
	Sweden	3.9%		US	
Kenya	Netherlands	13.5%	Kenya	Indonesia	
	Pakistan	11.3%		Malaysia	
	UK	9.4%		Uganda	
	Egypt	5.0%		Tanzania	
	Uganda	5.0%		Argentina	
	UAE	4.5%		Russian Fed.	
	Germany	3.9%		Pakistan	
	US	3.4%		India	
	France	2.6%		Egypt	
	Russian Fed.	2.6%		Australia	
Rwanda	DRC	36.6%	Rwanda	Tanzania	
	Pakistan	8.4%		Kenya	
	US	7.3%		Indonesia	
	Uganda	7.2%		India	
	UK	5.3%		Russian Fed.	
	Kenya	5.3%		Malawi	
	Ethiopia	3.4%		Malaysia	
	Germany	2.4%		Belgium	
	South Sudan	2.4%		Egypt	
	Netherlands	1.9%		Pakistan	
Tanzania	India	19.8%	Tanzania	Indonesia	
	Vietnam	10.5%		Russian Fed.	
	Kenya	8.9%		Malaysia	
	China	8.6%		India	
	Uganda	5.0%		UAE	

	Pakistan	4.1%		South Africa	
	Japan	3.8%		Pakistan	
	Rwanda	3.7%		Kenya	
	Germany	3.7%		Zambia	
	Netherlands	2.6%		Turkey	
Uganda	Kenya	16.3%	Uganda	Kenya	
	Italy	12.1%		Tanzania	
	Germany	8.7%		Indonesia	
	Netherlands	6.3%		Argentina	
	US	6.1%		Russian Fed.	
	South Sudan	5.9%		India	
	India	3.3%		Malaysia	
	Spain	3.2%		Rwanda	
	China	2.7%		Egypt	
	Pakistan	2.7%		China	

Source: Africa Agriculture Trade Monitor/ 2023 Report

According to the data presented in table 3.4, only two EAC members (DRC and Uganda) fall among the top destinations of agricultural exports from Burundi. For agricultural imports, Uganda, Tanzania and Kenya are among the top five sources agricultural imports for Burundi. Uganda is the only EAC country among top ten agricultural export destinations for Kenya. Uganda and Tanzania are the main sources of Kenya's agricultural imports. DRC, Uganda and Kenya are the main agricultural export destinations for Rwanda's agricultural products in the EAC. Tanzania and Kenya are the main sources of agricultural imports for Rwanda. Kenya is the only EAC country falling within the top ten category of destinations for agricultural exports from Tanzania. This could be attributed to low productivity in the sector. Most countries are unable to produce enough quantities of agricultural commodities for domestic consumption and export.

It is worth noting that formal trade might not be a true reflection of actual trade statistics in the EAC. This is because substantive amounts of informal trade take place across the borders. The proportion of informal trade in agricultural products varies across borders. Therefore, some borders record high volumes of informal trade for example the Tanzania-Burundi border.

Compared to other African RECs, agricultural trade in the EAC is highly introverted. This is due to high level of protection. The levels of protection are higher in the agricultural sector and is aimed at protecting farmers. However, it can turn to be counterproductive by undermining food security through higher consumer prices of agricultural commodities.

3.3 Problem Statement

Trade leads to static and dynamic gains to a country but such gains are not always equally shared by all countries. Both Classical and Neo – Classical economists advocated for international trade to enhance market expansion and division of labour. Eliminating agricultural sector inefficiencies is necessary in promoting its productivity. The SDG 2, seeks to end hunger, enhance food security, improve nutrition and promote sustainable agriculture. This calls for higher agricultural output through adjustment and elimination of trade restrictions, distortions and inefficiencies in agricultural markets.

Despite the existence of EAC free trade protocol and agriculture being the dominant economic activity, the region imports many agricultural commodities. Food inflation and insecurity coupled with low productivity levels are major issues affecting the agricultural sector in the region. The question as to whether agricultural trade openness has increased productivity in agriculture remains unanswered. This is the reason for investigating the nexus between trade openness and agricultural productivity.

3.4 Research Questions

The general research question for the essay is: What is the role of trade openness on agricultural productivity in the EAC? The specific research questions will be;

(i) What is the role of trade openness on agricultural productivity within EAC?

(ii) What is the causal relationship between agricultural trade openness and agricultural productivity?

3.5 Objectives of the study

The main study objective is to determine the effect of agricultural trade openness on agricultural productivity in the EAC. The specific objectives are to:

(i) Determine the effect of agricultural trade openness on agricultural productivity.

(ii) Examine the causal relationship between agricultural trade openness and agricultural productivity.

3.6 Justification of the study

Growth in agricultural trade is very significant to the welfare of rural households which directly depend on the sector. Agricultural trade leads to transformation of livelihoods in economies which mainly depend on agriculture. Increases in exports of agricultural products improve incomes earned by farmers from agricultural production (Ouma, 2017). Trade policies are important in influencing the agenda for industrial growth of any country. Trade openness leads to exposure of local production to foreign competition. This contributes to both technical and economic efficiency in agricultural production (Djokoto, 2012). .

The interrelationship between trade in agricultural products and livelihoods of rural populations happens in different ways. Production and sale of agricultural commodities enhances incomes of farmers which then stimulates demand for consumer goods. The increase in demand leads to creation and diversification of industries and more job opportunities mainly in upcoming urban areas neighbouring agricultural farm lands.

The agricultural sector significantly contributes to the accumulation of real GDP through generation of agricultural surplus. This expands output in the agricultural sector. Reforms in trade policies provide encouragement and motivation in the movement of factors of production. Such mobility results in efficient and effective allocation of resources in the domestic economy and welfare improvements. Trade can stimulate growth since the removal of barriers to international trade facilitates openness, accessibility and transfer of technology between countries. As markets expand, there is efficient use of resources in the domestic economy which stimulates the production of exportable products (Malefane & Odhiambo, 2018).

3.7 Literature Review

This section reviews major theories in the development of trade. It also reviews previous empirical studies on how trade openness affects productivity in agriculture. It then presents the overview of literature by identifying the main gap in literature that the study intends to fill by highlighting its key contribution to literature.

3.7.1 Theoretical Literature Review

Various theories explain the development of trade. This study discusses various trade theories that explain the evolution of trade between countries.

3.7.1.1 The Mercantilism Theory of Trade

This theory of trade advocated for government regulation of the economy and trade with the interest of promoting domestic industry at the expense of other countries. It proposed that the amount of exports should be higher than those of imports so as to make countries increase their wealth and become powerful. According to the theory, a nation's wealth was viewed in terms of precious metals (mainly gold and silver). A country could accumulate enough gold through exports. Importation of goods was viewed to be less beneficial because it was interpreted as giving away gold. Countries that exported more commodities accumulated more gold that could be used to expand their military capacities and global influence.

The theory advocated for protectionist policies to increase gains from exports and reduce losses from imports. Mercantilism was therefore against free trade which promoted economic wellbeing of nations through reduction of tariffs and fair free trade. This was because the theory mainly encouraged exports to create and accumulate wealth without promoting imports in equal measure (Blaug, 1978). The theory was criticized because it promoted government regulation and monopoly which tend to increase inefficiency and corruption. It was also criticized on the basis that it would make some people benefit at the expense of others (zero sum game where one's gain is a loss to the other). This could impoverish other countries as well as harm global growth and prosperity. The view of trade being a zero sum game was challenged by Smith (1776) & Ricardo (1817) who indicated that all nations trading together could gain even when some benefitted more than others. The three main issues of international trade which mercantilists failed to address included; gains from trade, structure and terms of trade (Ekelund & Tollison, 1981).

3.7.1.2 The Classical Theory of Trade

Mercantilist theories became an obstacle to economic progress. The theory advanced by Mercantilists favoured producers of commodities to the disadvantage of consumer interests. It is the classical economists who attempted to address the weaknesses of mercantilist theories. The classical theory was composed of: Absolute Advantage Theory (Smith, 1776) and Comparative Advantage Theory (Ricardo, 1817).

The Absolute Advantage Theory (Adam Smith, 1776)

The theory was proposed by Adam Smith (Smith, 1776). It explains the benefits which accrue to countries when they actively participate in the division of labour at the international level. Adam smith explained that specialization in a particular line of production leads to output increase. He therefore advocated that a countries participating in international trade should concentrate in producing goods where they enjoy absolute advantage. The country may then export some surplus of the locally produced goods while importing goods produced cheaply by its trading partners. According to Smith(1776), the approach was expected to lead to global efficiency (Anowor, Ukweni, & Ikeme, 2013). The theory by Adam Smith was based on certain assumptions; two countries participated in the trade, the two countries traded on two goods and the level of resource input in the countries were the same.

The Comparative Advantage Theory (David Ricardo, 1817)

The theory explained that benefits could accrue to countries between themselves even if one of the countries had absolute advantage over its trading partner in producing two goods. Comparative advantage is realized when a country engaged in trade, produces some product which will be sold at higher price outside the country. Suppose each country concentrates on producing goods in which it enjoys a comparative advantage, the amount of output produced will expand leading to an increase in the amounts of wealth in both countries (Ricardo, 1817).

According to Krugman & Obstfeld (1991), the Ricardian model was criticized on the basis that it did not factor the contribution of economies of scale in trade development. The classical theory of trade was criticized that it did not explain why in certain circumstances there were large flows of trade between nations whose economic structures were not different.

3.7.1.3 Neoclassical Theories of Trade

This was introduced by (Heckscher, 1919) & (Ohlin, 1933). The theory was later called Heckscher Ohlin (H-O) trade theory.

Heckscher-Ohlin theory

It attempted to explain the contribution of relative factors of production in determining international trade patterns. According to this theory, trade exists due to variations in comparative costs arising from unequal endowments in relative factors among countries. Countries should use locally available factors of production to produce goods for export while importing locally scarce goods. The theory emphasizes that countries should rely on factor endowment. This provides a link between trade among countries and mobility of labour and capital across countries.

The H-O theory assumes that: transport costs and impediments to trade are nonexistent; the commodity and factor markets exhibit perfect competition; constant returns to scale production technology applies to all production functions and different production functions exist between commodities but the same production functions exist in both countries. According to Jhingan (2006), many economists feel that this theory added value by improving the quality of comparative advantage.

Based on the H-O theory, a country exports a commodity whose production requires more use of a factor that is relatively cheap and abundant. However, the same country imports goods whose production requires intensive use of a factor which is expensive and scarce. The theory therefore implied that differences in the intensity of factors applied in production of goods alongside the real differences in factor endowments among countries explained the variations in international comparative costs of production.

The model was first tested empirically by Leontief (1953) which led to the Leontief paradox. The results of Leontief analysis showed that the USA (which has abundant capital) exported products which required more labour and imported products requiring more capital. These were contradictions to the H – O model. Other extensions of the H – O theory include Stopler & Samuelson (1941) and Samuelson (1948) theory on factor – price equalization. It postulated that increase in commodity prices improves the earnings of factors used intensively in producing a commodity.

3.7.1.4 The Modern Theories of Trade (New Theories of Trade)

Most of theories already discussed in this study do not describe the different kinds of trade witnessed in the world today. The data on world trade currently has a number of stylized facts that may be inconsistent with the classical and neo - classical trade theories. This has given rise modern trade theories. These theories explain the presence of economies of scale, imperfections in markets and differentiation of various products among other factors. The theories further explain global trade patterns whereby countries which produce similar products trade together. Such patterns have contributed to monopolistic competition where several companies dominate the global market. The main argument is the existence of a trade-off between the extent to which firms can achieve scale economies and the intensity of market competition.

3.7.1.4.1 Neo – Technological Trade Theories

The theories explained the contribution of gaps in technology and innovation among nations, firms and industries to be the main sources of international trade.

Linder's Theory

According to (Linder, 1961) trade among countries happens when such countries have same levels of income and demand patterns. The theory indicated that most global trade is concentrated among developed nations whose per capita income levels are similar compared to trade between developed countries and LDCs.

Posner's Theory

Posner (1961) theory analyzed how technological development affected trade. He regarded production technology improvements as an evolving process which determines international trade patterns. Production of a new good through technological innovation in a country may lead to imitation and demand gap in other countries. The extent to which countries will trade between themselves depends on the net effect of the demand lag and imitation gap.

The theory of imitation gap tries to explain the steps involved in innovation and imitation and how they affect trade patterns. Innovation of a new product by a domestic firm increases its profitability because it leads to temporary monopoly in the market (Anowor et al., 2013). The export of the product to foreign markets makes the firm to gain absolute advantage in its production. After sometime the profit of the innovating firm encourages imitation in another country. The firm will continue exporting the product while having comparative advantage until the importing country learns the new process, changes its equipment and plants in order to produce it. The technological gap theory was believed to be more relevant when compared with the traditional theories because it analyzed how changes in technology affected patterns of trade among countries.

Vernon's Product Cycle Theory

Vernon (1966) model generalized and extended the technological gap model. According to the theory, new products are developed through series of stages or cycles which lead to variations in their comparative advantage along the stages of development. The life time of a product passes through three stages; new product, maturity and standardized product. Posner emphasized time lag in the imitation process while Vernon's product cycle model emphasized the process of standardization. While the H – O model explained static comparative advantage, Vernon and Posner's models explain dynamic comparative advantage.

3.7.1.4.2 Intra – Industry Trade Models

These models described trade between nations which export and import similar products that are differentiated. The models recognized internal scale economies among firms and differentiation of products in describing trade between similar economies. The models include:

Krugman's Model (1979)

The model recognized the contribution of scale economies and monopolistic competition in trade. The model explains that trade between nations with similar tastes, technology levels, endowment of factors and income is due to differentiation of products and internal scale economies in production. This happens under a monopolistic framework of competition. The model implied that trade improves the welfare of consumers through increased choice of goods available to the consumers. It also implied that upon facilitation by scale economies, trade may lead to increases in demand, production and real income (Krugman, 1979).

Brander – Krugman Model (1983)

The model is based on oligopolistic competitive framework and explains the issue of dumping in trade between countries. In international trade, dumping is a practice by which countries export goods to foreign markets at prices lower than domestic prices. Reciprocal dumping explains situations where dumping results in a trade in the same product between two countries. The model thus explains the intra – industry trade involving homogeneous products but does not explain the contribution of trade on the welfare of a country (Brander & Krugman, 1983).

3.7.1.4.3 Strategic Trade Policy Models

The models attempt to justify why policies in the form of protectionism and subsidies for exports are important in promoting exports and increasing general welfare. The models were formulated through an assumption of oligopolistic competition in a partial equilibrium framework. The models were developed on the basis of trade wars between major industrialized nations. The models include;

Krugman's Model (1984)

The model provided justification that protecting local producers can result in promotion of exports. It considers three scale economies: Static internal economies; Dynamic economies of learning by doing and Economies in Research & Development and investment.

Brander & Spencer's Model (1985)

The model explains how subsidized exports may enable local producers to access some foreign markets (third country markets) ahead their rivals. It is a two stage model where governments choose levels of subsidy in stage 1 while firms choose output levels in stage 2. Each country has no domestic consumption which means all production is aimed at third country markets. An assumption is made that the foreign firms do not subsidize their exports. Subsidized exports to domestic firms reduce their cost of production which enables them to expand and capture large market shares in those markets ahead of rivals

Porter's National Competitive Advantage Theory (1990)

According to Porter (1990) patterns of trade are influenced by business and economic level in the trading countries. He emphasized four pillars (Diamond of National Advantage) to a country's competitive advantage when compared against other countries. He recommended that countries should export commodities when the four pillars are favourable and import when they are unfavourable. Governments should ensure that high production qualities are maintained by businesses, services are delivered and there is healthy competition among firms (Grant, 1991).

New Trade Theories Vs Traditional Trade Theories

The main emphasis of traditional trade theories was on comparative advantage. This was based on the argument that countries trade on their differences in production costs. However, the new trade theories advanced the argument that increase in returns to scale (where costs of production decrease as output as output expands) is the major determinant of trade patterns. They also argue that trade provides countries with a mutual gain even if there are no variations in their resource endowments or technology. This is attributed to availability of a wide variety goods to the consumers which lowers the cost of such goods. In summary, traditional trade models laid more emphasis on productivity differences in explaining international trade patterns. However, the new trade theories relaxed the CRS assumption by explaining that increasing returns may enhance trade flows between similar countries which do not have differences in productivity and factor endowment.

3.7.2 The Transmission channels between trade and productivity

Various economic growth theories have been presented in literature which explain that variations in growth is attributed to differences in productivity growth and factor inputs per unit. Such theories have identified transfer of technology, scale economies, competition in markets, allocation of resources and government policy as the main transmission mechanism linking trade to productivity growth.

Technology transfer takes place through trade. Importation of capital goods and intermediate inputs promotes the technology transfer between countries. Acquisition of a higher quality inputs contributes to increase in output as input prices remain unchanged which leads to growth of productivity (Connolly, 2003, Sunge& Ngepah 2020). Repeated interaction with new technology enables workers to improve their efficiency and productivity. This leads to accumulation of human capital which contributes to enhanced productivity. Investments in research leads to secondary discoveries which have positive effects on productivity. Improved productivity produces positive externalities which increases knowledge stock.

Trade enables a country to enjoy the benefits of scale economies. Such countries are able to achieve more gains due to increase in traded goods and trading partners. Through trade, smaller countries enjoy higher gains in economies of scale because large countries already have bigger markets. Trade openness enlarges markets in small countries. The expanded markets lead to improved productivity (Soo,2013; Sunge & Ngepah, 2020). The expansion of markets can also promote access and acquisition of better technology. Competition is also another channel linking trade to productivity. Trade openness enables cheaper and high quality imports to freely compete with local goods. According to Neoclassical economists, competition generated by imports enables a country to invest in technology and improve its efficiency and productivity. Increased competition makes inefficient producers to reduce their inefficiencies.

Allocation of resources across firms can also lead to disparities in productivity levels and income. Free trade in developing economies may lead to import dependency thus affecting domestic productivity. This may lead to vulnerability of the economy to external shocks which could further result in low productivity. The shocks may originate from sudden changes in trade terms, volatilities in prices and commodity production. The 2008 Global Financial Crisis affected open economies more than closed economies. Government policy on trade openness can influence the adoption of policies that make domestic firms to enjoy competitive advantage in international trade. Such policies could include tax incentives and zero rating of agricultural inputs so as to reduce the cost of production. Government policies can also lead to political stability and absence of insecurity. This can create a conducive environment for investments that enable the private sector to thrive (Malefa, 2020).

Based on trade flows, agricultural exports and imports can exert different effects on agricultural productivity. Competition as a result of import trade may affect domestic market prices. Prices of domestic agricultural prices may be depressed thus leading to negative growth in agricultural productivity. This may affect agricultural production in the domestic economy (Berger et al, 2021). Alternatively, competition generated by imports may stimulate improvement of domestic production technologies, enhanced investment in R&D and upgrading of agricultural machinery and equipment.

3.7.3 Empirical Literature Review

Teweldemedhin & Van Schalkywk (2010) analyzed how openness affected productivity of agriculture in South Africa. Estimation of results by error correction model using cross sectional data analysis revealed a positively significant effect of capital formation on agricultural export shares. Shares of imports and rates of real exchange negatively affected the levels of productivity in agriculture. There was a positive net effect of both exports and imports which indicated that openness had led to growth in productivity.

Dragan & Saleem (2010) assessed how trade openness affected agricultural productive efficiency in the US using the DEA approach. The study showed that efficiency change had improved due to reduction in agricultural imports as a result of protectionism measures adopted by the country. The contribution of agricultural exports to the sector's GDP did not affect the efficiency level of output from agriculture. The results were viewed to have been influenced by the agricultural dynamics and the policies of US.

Djokoto (2012) assessed how trade openness affected the productivity of agriculture in Ghana from 1995 - 2009. The paper revealed that FDI and openness did not have any long run relationship. FDI had a significant negative contribution on output from the agricultural sector. The paper provided evidence which could be used by policy makers to properly examine the various types of FDI being channeled to agriculture. Due to the negative impacts that international free trade may have on local agricultural productivity, the study advocated for re- evaluation of policies on free trade to boost productivity and output in the agricultural sector.

Anowor et al. (2013) examined how liberalized trade affected the productivity levels of agriculture in Nigeria by focusing on the export sub sector. The study showed that liberalization of trade had significantly influenced the productivity of agricultural sector and export sub sector. The study thus recommended the formulation policies aimed at enhancing investments in capital formation and attracting FDI to the sector. This was expected to contribute to output expansion and promotion of agricultural exports.

Nirodha et al. (2014) quantitatively analyzed how trade specific policies affected agricultural productivity in Sri Lanka from 1960- 2010. Macro level data were estimated using various models of multiple regressions to examine the contribution of reforms on trade policies on productivity of agriculture. The study showed that liberalization of trade had a positive influence on levels of productivity in agriculture. The study concluded that openness; levels of investment and rates of interest influenced on output growth in agriculture.

Sotamenou & Negwelah (2018) analyzed the effect of open trade on agriculture in Cameroon between 1980 – 2015. Fully Modified Ordinary Least Square (FMOLS) technique was used in estimation. The study showed that free trade policies in the post – liberalization period (1995 – 2015), facilitated free movement of agricultural goods which led to growth of agricultural output. Various indicators including capital formation in agriculture, FDI, crop land and rates of interest significantly influenced agriculture growth which was an indication that growth of investment in agriculture positively stimulates agricultural output.

Sunge & Ngepah (2020) examined how openness and regional trade agreements affected efficiency of agricultural productivity in Africa. The study used stochastic frontier approach in the analysis. The results suggested that RTAs had favourable effects on technical efficiency which varied among crops and membership. It was further discovered that corruption control increased technical efficiency while regulatory quality reduced it. The study recommended the enhanced role of RTAs in order to promote liberalization of agricultural trade.

Mwangi et al. (2020) investigated the relationships between agricultural imports, agricultural productivity and economic growth in SSA over the period 1990-2015. Granger causality test was used to infer the causal relations between variables. The instrumental variable technique of the generalized two stage least squares was used in generating the effects and controlling for endogeneity. The bootstrap procedure was applied in dealing with cross sectional dependence. The results showed a bi-directional causality between agricultural imports and agricultural productivity. Imported agricultural inputs significantly influenced agricultural productivity.

Yuan et al. (2022) analyzed the contribution of international trade on productivity of agriculture among 126 countries during the period 1962 – 2014. The paper evaluated how trade affected agricultural productivity following the transition from GATT to WTO. In addition to deriving spillover effects that had been overlooked, it discovered that trade was an impediment to agricultural productivity growth during the GATT period. However, in the WTO period, there were improvements in agricultural productivity as a result of trade.

Xu et al. (2023) investigated how trade on agricultural commodities impacted on TFP among the G20 countries. Besides discovering the influence of technical progress, it was also found that agricultural trade significantly improved the productivity levels in agriculture. Based on trade flows, the effect of exports on agricultural productivity was stronger than imports. To sustain and improve the strong effect of exports on productivity, the study recommended the strengthening of the institutional environment. International trade was found to affect productivity in two ways. By importing goods, there is information flow into the importing country about the techniques of producing such imports. Through exports, valuable feedback from buyers can lead to upgrading of production technology and acquisition of better managerial skills. International trade has the potential to increase competition and innovation levels thus resulting into productivity growth.

3.7.4 Overview of Literature

A review of the theories indicates that there is no specific theory which explains how openness in agricultural trade affects productivity changes in agriculture. The issues of interest in this study cuts across the various theories of trade presented in the literature. The reviewed empirical literature shows that openness influences agricultural productivity. These studies except Xu et al, (2023), have used openness index calculated using all exports and imports to assess its effect on agricultural productivity. This study addresses this limitation by using agricultural trade openness calculated using agricultural exports and agricultural imports. The reviewed studies failed to include governance variables in the analysis. The study introduces government regulatory quality as one of the key variables that influences the trade orientation in a country. Existing studies overlooked the effect of slope heterogeneity and CSD. This may lead to inconsistent and biased estimates. None of the previous studies has analyzed the contribution of EAC trade protocol on agricultural productivity in the region. These are the issues which this study aims to address.

3.8 Methodology

This section explains the theoretical background, specifies the estimated model, diagnostic tests variables and data sources.

3.8.1 Theoretical framework

The foundation of this study from theory is the Neo – Classical Solow growth model. In the Neo classical growth model; capital, labour and technology of production determine the total output in a production process over a given time period (Solow, 1979). The model begins with a Cobb – Douglas (C-D) production.

$Y = AK^{\beta}L^{1-\beta}$ ……………………………………….… (3.1)

The study is then modeled along the aggregate production function framework. Models derived from the aggregate production function have been applied to assess how trade affects productivity in agriculture. In the aggregate production function, an assumption is made that in addition to the main production factors; labour and capital, other variables like trade may be added in the model to examine their contributions on agricultural productivity. The aggregate production function framework was used by Fosu & Frimpong (2006) and Herzer et al., (2006).

Romer (1986) and Lucas (1988) proposed an extension of Solow model by including human capital. This was necessitated by the view that human capital could contribute to technology innovation and hence promote productivity growth. The resulting model which was endogenous growth theory allowed for the inclusion of other variables in the production function (Anaman, 2004). A new model is then generated based on a C-D production function.

$Y_{it} = A_{it}K_{it}^{\beta}L_{it}^{\alpha}$ ………………………………………………….. (3.2)

Where Y_{it} is the output, A_{it} represents the TFP, K_{it} is capital, β is the output elasticity of capital, L_{it} represents the labour and α is the labour output elasticity. The TFP contributes to changes in output and relies on technology and efficiency to enhance output growth. The transfer of technology takes place through openness in trade. Given that the research objective is to examine how agricultural trade openness affects the productivity of agriculture, we make an assumption that TFP is composed of various factors that determine agricultural productivity (Teweldemedhin & Van Schalkywk, 2010).

$A_{it} = f\ (ATO, AES, AIS, REER, GRQ, EAC, GCFA, AGR\_LABOUR)$ …….. (3.3)

Where

ATO: Agricultural Trade Openness

AES: Agricultural Export Share

AIS: Agricultural Import Share

REER: Real Effective Exchange Rate

GRQ: Government Regulatory Quality

EAC: Dummy variable for EAC Trade Agreement

GCFA: Gross Capital Formation in Agriculture

AGR_LABOUR: Agricultural Labour

3.8.2 Model Specification

Following Sakyi (2011), the following model is specified to estimate the impact of openness on agricultural productivity.

$$AGPI_{it} = \alpha_i + \beta_i x'_{it} + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.4)$$

$i = 1,2, \ldots \ldots .., M$

$t = 1,2, \ldots \ldots ., T$

Where;

$AGPI_{it}$ = Agricultural gross productivity index

$i =$ Cross section dimension (individual countries)

$t =$ Time dimension of the data

α_i = Country specific intercept

$\beta_i = \beta_{1i}, \beta_{2i}, \ldots\ldots\ldots \beta_{ni}$

$x_{it} = x_{1it}, x_{2it}, \ldots \ldots, x_{nit}$ are the explanatory variables

$n = 1,2, \ldots .. N$ (n is the total regressors)

ε_{it} = error term

From equation 3.5, the analytical model for estimation is specified as;

$$lnAGPI_{it} = \alpha_i + \beta_1 \ln ATO_{it} + \beta_2 \ln AES_{it} + \beta_3 \ln AIS_{it} + \beta_4 \ln REER_{it} + \beta_5 lnGRQ_{it} + \beta_6 \ln EAC_{it} + GCFA_{it} + AGR\_LABOUR_{it} + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.5)$$

3.8.3 Model Estimation

Panel estimation methods are categorized as static and dynamic estimation methods. The difference between static panels and dynamic panels is that a dynamic panel includes lagged values of the dependent variable as regressors. Static panels are mis-specified in most cases because of the serially correlated within group disturbance terms. Another weakness of static panels is the assumption of cross sectional independence. Dynamic panels are richer in economic content because they are able to distinguish between short term and long term impacts of regressors.

3.8.3.1 Panel long run estimation

The test is used to investigate the nature of long term relations between variables. In the presence of cointegration, OLS does not provide efficient estimates. FMOLS and DOLS are therefore used in estimating long run estimates because they control for potential bias. Based on simulations, DOLS estimation is superior to FMOLS (Kao & Chiang, 2000). For robustness, Canonical Cointegration regression (CCR) is also estimated. The difference between the three methods lies in the various techniques they use in controlling for possible causes of bias in the cointegration regression estimates. While FMOLS is deterministic, DOLS uses leads and lags while CCR applies internal transformations to control for bias in the regression estimates.

3.8.3.2 Panel Granger Causality Analysis

The existence of long run relationships between the variables is tested using cointegration tests. However, such tests cannot reveal the nature of causality between variables. We apply panel causality analysis developed by Dumitrescu & Hurlin. This is due to heterogeneity of the cross sectional units. An assumption is made that due specific characteristics unique to each country assume that there may be causal relations for some units and not others. The method applies a bootstrap procedure for estimation when presence of CSD is confirmed (Lopez & Weber, 2017).

3.8.4 Diagnostic Tests

3.8.4.1 Panel Unit Root test

The test is used to confirm if unit roots are present in panel data. The tests include; LLC (2002), IPS (2003) and Breitung (2000) unit root tests. LLC (2002) & Breitung (2000) tests make the assumption of homogeneity for all members of a panel in the dynamics of the autoregressive coefficients. In this study IPS (2003) test for unit roots is applied because it allows for the existence of various autoregressive parameters among members of a panel and the short run dynamics under the alternative that there is a stationary trend. For robustness, we test for panel unit roots using the three tests.

3.8.4.2 Cross Sectional Dependence (CSD) Test

In testing for causality across countries using panel granger causality tests, the effects of globalization and openness may lead to cross sectional dependence. Countries are increasingly getting integrated in finance, trade, education and other sectors which may cause transmission of shocks across countries thus leading to cross correlation of errors. An example was the global financial crisis and the Eurobond whose effects were felt across the world (Olabisi & Evan, 2018). The test is done using Pesaran (2021) CSD test. It is an upgrade on Pesaran (2015) test and generates four test statistics for each variable.

3.8.4.3 Slope Homogeneity test

Heterogeneity across countries is a critical factor for consideration in testing for bootstrap panel causality. The assumption of homogeneity in the model parameters may not detect heterogeneity that could be attributed to specific characteristics of a country (Breitung, 2005). If slope heterogeneity is confirmed in a data series, it shows that economic results in one EAC country may not be experienced in other countries. The slope homogeneity tests will be investigated using Pesaran & Yamagata (2008). The test is preferred because of its reliability in models for panel data. The test is specified as follows:

$$\tilde{S} = \sum_{i=1}^{N}(\hat{\beta}_i - \hat{\beta}_{WFE})' \frac{x_i' M_\tau x_i}{\hat{\sigma}_i^2} (\hat{\beta}_i - \hat{\beta}_{WFE}) \quad \text{...}$$

Where $\hat{\beta}_i$ is the OLS (pooled) and $\hat{\beta}_{WFE}$ is the pooled estimator of the weighted fixed effect and the estimator is $\hat{\sigma}_i^2$. The statistics for standard dispersion are specified as:

$$\widehat{\Delta} = \sqrt{N}\left(\frac{N^{-1}\hat{S}-k}{\sqrt{2k}}\right) \quad \text{...}$$

3.8.4.4 Test for Autocorrelation and Heteroskedasticity

The existence of serial correlation may result to biased standard errors which may affect the efficiency of results. Testing for the existence of serial correlation in the panel dataset is therefore considered to be necessary (Drukker, 2003). The comparison between the standard delta test and the Heteroskedasticity and Autocorrelation Consistent (HAC) test proposed by Blomquist & Westerlund (2016), is applied in this study. The test by Born and Breitung (2016) which has been corrected for bias is then used to further test and confirm the presence of autocorrelation. The test provides the Q test statistics and the Lagrange Multiplier (LM) test statistics.

3.8.4.5 Test for Multicollinearity

Multicollinearity arises when two or more independent variables are correlated. The existence of such a correlation complicates the process of determining the effect of regressors on the response variable. Due to the nature of our independent variables, agricultural trade openness, agricultural export share and agricultural import share, it is necessary to do the test. The Variance Inflation Factor (VIF) is used in the estimation.

3.8.4.6 Panel Cointegration test

Cointegration may exist among variables due to their relationships in the long run. Testing is used in the hypothesis test of stationarity in variables whose linear combinations are used in the estimation. Therefore, all stationary variables can achieve long run equilibrium by moving together. Pedroni (2000, 2004) cointegration test and Westerlund (2007) test are applied in this study.

3. 8.5 Measurement and Description of Variables

Agricultural Gross Productivity Index (AGPI): This is defined as the relative aggregated agricultural production volume for each year which is calculated with reference to a set period (base).

Agricultural Trade Openness (ATO): Openness is the nature of trade orientation adopted by a country whereby a country trades with other countries (open trade). It may also be described as outward orientation in which various economies explore opportunities to trade with other countries. It is determined by the ratio of agricultural trade the GDP. Openness may create trading opportunities for goods produced domestically. The expanded market can lead to higher output and productivity. Alternatively, increase in openness could allow importation of cheap agricultural commodities which may negatively affect productivity

Agricultural Export Share: This is the ratio of agricultural exports to total agricultural production for an individual country in a year. Increased agricultural export share is expected to enhance agricultural productivity.

Agricultural Import Share: This is the ratio of agricultural imports to agricultural production for a country in a given year. A high amount of agricultural imports may negatively affect agricultural productivity. However, increase in imports of agricultural inputs may promote productivity.

Real Effective Exchange Rate (REER): It measures the currency value when compared with the average weight of various foreign currencies which is then subject to division by the price deflator or cost index. Increases in the value of REER imply that imports are relatively cheaper compared to exports. This is an indication that increases in REER contributes to loss of competitiveness in trade. REER may negatively or positively affect the index of agricultural productivity.

Government Regulatory Quality (GRQ): It shows the perceived government actions in formulating and implementing policies that promote private sector development. It is measured as a percentile rank for a country against other countries with 0 being the lowest and 100 the highest. It is also measured as a range between -2.5 (lowest) and 2.5 (highest).

Gross Capital Formation in Agriculture: It is the capital investment in agriculture. It consists of additions to capital assets of farmers. It is expected to positively influence agricultural productivity.

Agricultural Labour: This is the number of farm workers per year expressed as a percentage of total labour force in a country. Agricultural labour is expected to positively contribute to agricultural productivity. However, low quality of agricultural labour may affect productivity.

EAC: This is used as a dummy variable to represent EAC membership. Membership to the EAC may enable a country to enjoy other benefits apart from trade such as conflict resolution and peace building which may boost trade and productivity. An example was the intervention of EAC members during the post-election conflict in Kenya in 2007. In 2023, the EAC intervened to address the conflict in DRC by sending peace keeping troops to the country. In West Africa, ECOWAS intervened to restore peace after disputed presidential elections in Ivory Coast (2010) and The Gambia (2016).

3.8.6 Data Sources

Annual data on Agricultural Gross Productivity Index (AGPI) was accessed from FAO AGROSTAT data set. Data for computation of Agricultural trade openness, Agricultural export share, Agricultural import share is accessed from International Trade Statistics published annually by the United Nations (UNCOMTRADE database) and WDI. Agricultural production data is accessed from FAO AGROSTAT. Data on capital and labour will be accessed from WDI. Data on REER is accessed from the International Financial Statistics (IFS) data set portal. Data on institutional quality (Government Regulatory Quality) is accessed from WDI.

3.9 Empirical Results and Discussion

3.9.1 Descriptive Statistics

Table 3.5: Descriptive Statistics

Variable	Mean	Std. dev	CV	Variance	Skewness	Kurtosis
AGPI	87.2892	22.66472	0.259650	513.6895	-0.29472	2.83143
ATO	0.2992	0.20678	0.691109	0.04275	0.89523	2.8233
AES	0.09508	0.10152	1.06773	0.01030	2.68026	12.52852
AIS	0.02052	0.01704	0.830409	0.0002905	8.19634	82.78287
REER	102.6583	17.6125	1.715643	310.2002	0.37208	4.382775
GRQ	35.30192	15.67883	0.444135	245.8258	-0.40685	2.060326
EAC	1.552	0.499289	0.321706	0.2492903	-0.209134	1.043737
AGR_L	73.6882	12.88683	0.174883	166.0705	-0.308445	2.226708
GCFA	19.77038	7.834965	0.396298	61.38668	0.511111	3.34048

Source: Author's computation

The statistics for the variables are presented in Table 3.5. The mean of agricultural productivity index is 87.28%%, an indication that agricultural productivity is not doing badly. The mean of agricultural trade openness is 0.2992, an indication that agriculture contributes 29.92% of the GDP in the region. The mean of agricultural export share is 0.09508. This implies that only 9.5% of the total agricultural production in the EAC is exported. The coefficient of variation (CV) shows that wide variations is not found across the variables. As a result, the means of the variables can be taken as the actual representation of data across EAC countries. The skewness statistic indicates that agricultural productivity, agricultural labour, institutional quality and EAC membership are skewed to the left. However, agricultural trade openness, agricultural export share, agricultural import share, real effective exchange rate and agricultural gross capital formation are skewed to the right. This shows that none of the variables has a perfect symmetry in its data distribution.

3.9.2 Panel Unit Root tests

Table 3.6: Panel unit root tests (At Levels)

Variables	LLC Test	Breitung Test	IPS Test
AGPI	0.2782 (0.6096)	2.8019 (0.9975)	1.8102 (0.9649)
ATO	-2.6849 (0.3006)	-1.3079 (0.9055)	-2.774 (0.2189)
AES	-4.5448 (0.3040)	0.3722 (0.3549)	-3.042 (0.1723)
AIS	-0.5956 (0.2757)	-2.7086 (0.1134)	-1.8419 (0.3327)
REER	-1.9391 (0.1262)	0.8562 (0.8041)	0.0333 (0.5133)
GRQ	-0.6945 (0.2437)	0.7102 (0.7612)	0.7917 (0.7857)
EAC	-0.7456 0.2280)	-0.3135 (0.3769)	0.7983 (0.785)
GCFA	-0.2389 (0.4056)	-0.6928 (0.2442)	-0.2354 (0.407)
AGR_LABOUR	-1.8949 (0.2291)	4.748 (0.7489)	2.858 (0.9979)

Source: Author’s computation using FAO and World Bank data

Table 3.6 provides panel unit root results generated using LLC (2002), Breitung (2000) and IPS (2003) tests. Based on the results, all variables are non-stationary. The results are not significant.

Panel Unit Root Tests (First Difference)

Table 3.7: Panel unit root tests at first difference

Variable	LLC	Breitung	IPS
AGPI	-3.7104 (0.0001)	-6.0528 (0.0001)	-6.334 (0.0000)
ATO	-7.8061 (0.0000)	-6.4442 (0.0000)	-6.6903 (0.00000)
AES	-6.2649 (0.0000)	-5.982 (0.0000)	-6.5178 (0.0000)
AIS	-3.0083 (0.0013)	-3.8727 0.0001)	-6.8263 (0.0000)
REER	-6.2516 (0.0000)	-6.2733 (0.0000)	-4.6745 (0.0000)
GRQ	-4.31 (0.0000)	-5.5714 (0.0000)	-4.6892 (0.0000)
EAC	-3.2688 (0.0005)	-7.1647 (0.0000)	-5.2557 (0.0000)
GCFA	-5.0888 (0.0000)	-6.0211 (0.0000)	-5.8786 (0.0000)
AGR_LABOUR	-1.3091 (0.0053)	-2.6118 (0.0045)	-1.937 (0.0000)

Source: Author's computation

Table 3.7 shows that at first difference, results are significant at 1%. The null hypothesis about presence of unit roots is rejected. This is a confirmation that the variables achieved stationarity after first differencing. Given that stationarity in the variables is achieved after differencing once, we conclude that our variables are I (1).

3.9.3 Panel cointegration tests

The test is used to check for the presence long term relationship in the variables. Pedroni (2000, 2004) test is preferred because it allows for panel heterogeneity across individual members of a panel. For robustness, we also perform Kao (1999) and Westerlund (2007) cointegration tests.

Table 3.8: Panel Cointegration test results

Kao test		
	Statistic	**p-value**
Modified DF t	-3.3642	0.0004
DF t	-1.8835	0.0298
ADF t	-0.7720	0.2201
Unadjusted Modified DF t	-4.5715	0.0000
Unadjusted DF t	-2.2357	0.0127
Pedroni test		
Modified PP t	2.5900	0.0048
PP t	-1.6336	0.0512
ADF t	1.4153	0.0785
Westerlund Test		
Variance ratio	0.4366	0.0312

The outcome of Pedroni cointegration test results in Table 3.8 indicates that the three statistics are significant by a majority of probabilities. Based on these results, the null of no cointegration is rejected. This is an indication that the variables have a long term relationship.

Slope Homogeneity Test

Table 3.9: Slope homogeneity results

Test	**Statistic**	**p-value**
Slope homogeneity $H_0: slope\ homogeneity$		
Delta	3.488	0.000
Delta adj.	4.503	0.000

Results in Table 3.9 indicate that the test statistics are significant at 1%. The null of slope homogeneity is rejected. This is a confirmation of slope heterogeneity in the panel. This implies that there are different economic outcomes for individual countries.

Allowing for heteroskedastic and serially correlated errors

Dynamic datasets are likely to suffer from autocorrelation. A comparison is done between the standard delta results and the Heteroskedasticity and Autocorrelation (HAC) robust estimator. The option uses HAC robust standard errors. The use of the HAC robust estimator makes the test to become heteroskedastic robust (Blomquist & Westerlund, 2013). Simulation results have shown that the standard delta test's performance relies heavily on the assumption of the residuals. Therefore, in order to obtain optimal settings, we compare the standard delta test outcome with the HAC robust equivalent. If there is a disagreement between the results, a warning is shown that there is possibility of autocorrelation occurring. The test result also indicates whether cross sectional dependence has been detected in the variables.

Table 3.10: Comparison of Standard Delta tests with HAC Robust Equivalent

Standard Delta Test	**Statistic**	**p-value**
Slope homogeneity $H_0: slope\ coefficients\ are\ homogeneous$		
Delta	3.488	0.000
Delta adj.	4.503	0.000
Delta HAC		
Delta	-2.349	0.019
Delta adj.	-3.033	0.002

The test results in Table 3.10 indicate that there is no warning about possibility of autocorrelation occurring. The two tests do not generate different results. However, the results show a possibility of CSD among the base variables.

3.9.4 Cross Sectional Dependence test

The EAC countries are found in the same geographical area. Most of economic activities among the EAC members are similar. Due to globalization, countries share many things in common. The regular interactions and proximity to each other means that any shock to the agricultural sector, trade or financial sector in one country can be easily affect countries. Cross sectional dependence (CD) arises because of some unobserved common factors which affect all units in different ways. Failure to account for those common factors between units of a cross-section leads to cross section dependence in the error term. In the presence of CSD, the assumption of the error term being identically and independently distributed is violated. In extreme cases, cross sectional dependence may lead to endogeneity or omitted variable bias which may result to inconsistency and bias of estimates. Pesaran CD test (2021) which is viewed as an investigation into the mean correlation between panels is applied in the study. The test provides four statistics and p-values for each variable

Table 3.11: CSD Exponent Estimation and Test

Variable	CD	CDw	CDw+	CD*
AGPI	8.66 (0.000)	6.89 (0.000)	34.02 (0.000)	0.56 (0.574)
ATO	-2.512 (0.149)	-0.50 (0.006)	10.91 (0.000)	0.29 (0.007)
AES	4.43 (0.000)	0.65 (0.051)	14.82 (0.000)	0.77 (0.440)
AIS	6.46 (0.000)	-1.32 (0.187)	20.12 (0.000)	1.07 (0.0286)
REER	-0.176 (0.855)	-1.06 (0.0287)	18.87 (0.000)	2.37 (0.001)
GRQ	0.25 (0.805)	0.50 (0.619)	16.83 (0.000)	0.97 (0.033)
EAC	15.32 (0.000)	2.92 (0.004)	51.37 (0.000)	1.23 (0.022)
AGR_LABOUR	5.71 (0.000)	0.38 (0.701)	20.80 (0.000)	4.07 (0.000)
GCFA	0.44 (0.006)	0.57 (0.045)	2.47 (0.000)	0.225 (0.019)

Table 3.11 results indicates that all test results are significant. We therefore reject the null of weak CSD based on the majority of probabilities. This implies that our panel is characterized by strong CSD. This means that the estimation methods applied in the study must control or account for strong CSD in the panel.

Testing for Multicollinearity

The association between two or more independent variables leads to multicollinearity. Presence of multicollinearity may lead to increased variability in a dataset, extreme sensitivity of a dataset to minor changes, instability in the empirical model and skewed as well as unreliable results. The VIF which measures the extent to which multi-collinearity has increased the variance of an estimated coefficient is used in testing for multicollinearity. It assesses the extent to which an explanatory variable can be explained by all other explanatory variables in the equation.

Table 3.12: Multi-collinearity test results

Variable	**Variance Inflation Factor (VIF)**	**1/VIF**
GRQ	3.93	0.254573
ATO	2.85	0.350670
AGR-LABOUR	2.64	0.379405
AES	2.12	0.471746
GCFA	1.88	0.532288
EAC	1.57	0.636893
REER	1.37	0.728770
AIS	1.08	0.929613
Mean VIF	2.21	0.419293

All the variables have VIF values less than 5 with a mean VIF value of 2.21. This is an indication that multicollinearity is not a major problem among the variables.

Testing for Heteroskedasticity and Autocorrelation

Presence of serial correlation may lead to inconsistency of estimates in a dynamic panel model. Omission or inclusion of time trends can alter estimates of parameters. Tests for serial correlation may help in the identification of an ideal model which is more credible statistically to complement theoretical arguments (Wursten and Leuven, 2018). The Woolridge-Drukker (Drukker 2003, Woolridge 2010) test mainly applies to autocorrelation of the first order and makes an assumption that the variance is constant overtime. In this paper, we apply the bias corrected serial correlation test proposed by Born and Breitung (2016) which is applicable in testing for autocorrelation up to any level or at a specific level. The test is suitable for cases in which N and T or both are smaller in size (Wursten and Breitung, 2018). The test calculates two bias corrected test statistics.

Table 3.13: Bias Corrected Born and Breitung (2016) Q(p) test

Variable	Q(p)-stat	P-value	N	Max T	Balance
AGPI	25.27	0.000	5	25	balanced
ATO	16.78	0.000	5	25	balanced
AES	3.77	0.152	5	25	balanced
AIS	43.54	0.000	5	25	balanced
REER	17.16	0.000	5	25	balanced
GRQ	38.19	0.000	5	25	balanced
EAC	5149.56	0.000	5	25	balanced
GCFA	12.60	0.002	5	25	balanced
AGR-LABOUR	8.15	0.017	5	25	balanced

According to the Q(p) test results presented in Table 3.13, the null of no serial correlation in the dataset is strongly rejected. Majority of the p-values are significant at 1%. This is an indication that there is serial correlation.

Table 3.14: Bias Corrected Born and Breitung (2016) LM (k) test

Variable	LM(k)-stat	P-value	N	Max T	Balance
AGPI	3.61	0.000	5	25	balanced
ATO	2.71	0.007	5	25	balanced
AES	1.38	0.167	5	25	balanced
AIS	2.09	0.037	5	25	balanced
REER	3.96	0.000	5	25	balanced
GRQ	1.39	0.164	5	25	balanced
EAC	61.77	0.000	5	25	balanced
GCFA	2.68	0.007	5	25	balanced
AGR-LABOUR	3.31	0.001	5	25	balanced

According to the results in Table 3.14, the null of no serial correlation is rejected at 1% by a majority of probabilities. This is a confirmation that there is serial correlation in the dataset.

3.9.5 Accounting for Heteroskedasticity and Autocorrelation

. Panel iterated generalized least squares test is applied in controlling for autocorrelation and heteroscedasticity. For robustness of our test results, we also perform Panel Corrected Standard errors test. Therefore, based on the results presented in Tables 3.9 and 3.10, we proceed to control for heteroscedasticity and autocorrelation.

Table 3.15: GLS and PCSE estimation results

Variable	Generalized Least Squares Estimation			Panel Corrected Standard Error Est.		
AGPI	Coefficient	Std. Error	p-value	Coefficient	Std. error	p-value
ATO	40.64443	8.996405	0.000	40.64443	7.402757	0.000
AES	-161.892	15.9164	0.000	-161.892	20.72017	0.000
AIS	-47.01395	69.50877	0.499	-47.01395	51.69486	0.363
REER	0.0801032	0.067287	0.234	0.0801032	0.0578041	0.166
GRQ	0.5154497	0.120882	0.000	0.5154497	0.1106878	0.000
EAC	12.68522	2.795266	0.000	12.68522	3.173516	0.000
AGR_LABOUR	0.6954405	0.143986	0.000	0.6954405	0.0965253	0.000
GCFA	-0.0371142	0.198628	0.852	-0.0371142	0.197313	0.851
_Cons	-5.135583	15.971115	0.748	-5.135583	9.27069	0.580
	Estimated Covariances 1			Estimated Covariances 15		
	Estimated autocorrelations 0			Estimated autocorrelations 0		
	Estimated coefficients 9			Estimated coefficients 9		
	Prob > Chi2 0.000			Prob > Chi2 0.000		

The results in Table 3.15, show that the panel is free of autocorrelation.

Accounting for Cross Sectional Dependence

In controlling for CD, approximation of the common factors can be done using principal components model (Bai, 2009) or by use of cross sectional averages (CSA) method (Pesaran, 2006). The common correlated effects estimator (CCE) method by Pesaran (2006) is commonly preferred because identification of the common factors in advance is not a requirement. If not accounted for, CSD may lead to inconsistency and bias in regression estimates. The strong CSD is approximated by adding CSA as additional covariates. The estimation involves a comparison between CCE pooled estimator and MG estimator (Pesaran, 2006).

Table 3.16: Comparison of Mean Group Estimator and Common Correlated Effects (CCE) Pooled Estimation

H_0: *slope coefficients are homogeneous*	
Delta	p-value
-1.55e+04	0.000
adj. -1.09e+04	0.000

Table 3.16 shows that after estimation using CSA of the variables, the effect of strong CSD is removed from the panel. The test results are significant at 1%.

3.9.6 Panel Long Run Estimation

The long run relationship among the variables is estimated using FMLS, DOLS and CCR. The three methods are used together to investigate if there are problems with the model specification. This is because our estimates may not be robust to alternative panel cointegration techniques of estimation. There could also be a bias because of the failure to recognize that that some coefficients may be heterogeneous. The three methods use different methods to control for potential endogeneity, cross sectional heterogeneity and serial correlation.

Table 3.17: FMOLS, DOLS and CCR Regression Results

Variable	**FMOLS**		**DOLS**		**CCR**	
AGPI	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
ATO	52.71977	0.000	47.81765	0.013	51.41753	0.000
AES	-203.1033	0.000	-213.5877	0.000	-196.9244	0.000
AIS	-71.47122	0.506	-96.46854	0.685	-46.71347	0.733
REER	-0.0002309	0.998	0.0157544	0.925	0.0049797	0.961
GRQ	0.7668967	0.000	0.7793668	0.003	0.7047023	0.000
EAC	7.665223	0.076	7.177785	0.268	8.221023	0.063
AGR_L	0.9008675	0.000	0.8507254	0.007	0.8570693	0.000
GCFA	-0.1035442	0.736	-0.2132925	0.641	-0.0673047	0.834
_Cons	-10.85063	0.661	-4.226446	0.908	-8.1885681	0.743
R-Squared	0.659977		0.7862623		0.6812957	
Adjusted R-Squared	0.6363232		0.7094129		0.659125	

According to results displayed in Table 3.17, FMOLS estimation results indicate that agricultural trade openness, government regulatory quality and agricultural labour have significant positive effects on agricultural productivity. A 1% increase in trade openness increases agricultural productivity by 52.719 units. A 1% increase in government regulatory quality increases productivity by 0.7668 units while a 1% increase in agricultural labour increases productivity by 0.9008 units. A 1% increase in agricultural export share decreases productivity by 203.1033 units. Agricultural export share negatively influences productivity. This can be interpreted to mean that most of the agricultural are in raw form which yield lower returns. This can lead to low investments in agriculture thus leading to low productivity. A 1% increase in agricultural import share reduces agricultural productivity by 71.47 units. Membership to the EAC is positive and significant. EAC membership positively contributes to productivity. The significance of government regulatory quality confirms the critical role played by institutional quality (government regulation) on trade matters. R squared is 65.99%, which shows that 65.99% of the variation in productivity is explained by the regressors.

The panel DOLS estimation results are similar to those of FMOLS. All the four variables which were significant under FMOLS are equally significant under DOLS with a slight variation in the coefficients. R squared is 78.62%, an indicator that 78.62% of changes in agricultural productivity is attributed to the model's regressors. The CCR results further confirm the results from FMOLS and DOLS estimations. All variables that were significant under FMOLS and DOLS are significant in CCR estimation with some variations in the coefficients. Since all the three estimation methods yield similar results, we can conclude that the model is not facing any specification problems. The variations in R squared values across the three methods is due to the different techniques they use to control for potential cross sectional heterogeneity, endogeneity and serial correlation.

The estimation results confirm the superiority of DOLS over other panel cointegration regression methods. The addition of leads and lags significantly reduces the bias associated with DOLS estimates compared to FMOLS and CCR estimation results (Kao & Chiang, 2000).

3.9.7 Panel Granger Causality

The method assumes that there can be a causality for some units but not all of them. The method does not provide any guidance on lag order selection. Its implementation procedure allows for the request of lag order choice so that AIC, BIC HQIC criteria can be minimized (Lopez & Weber, 2017). Given that the presence of strong CSD has been confirmed in the dataset, we apply the bootstrap granger causality procedure. The method is highly recommended to be used in computing bootstrap critical values in cases where CSD is confirmed.

According to Dumitrescu and Hurlin (2012), when T is larger than N, Z-bar should be considered in making a decision about rejection of the null hypothesis. However, if N is larger than T, then Z-bar tilde statistic should be used in making the decision to reject the null hypothesis. The non-causality between variables is the null hypothesis of the test. A causal effect exists when the null hypothesis is rejected. The procedure computes the Z-statistics using optimal number of lags before performing bootstrap replications. We perform 2000 bootstrap replications for testing of causality between each pair of variables.

Table 3.18: Panel Causality results

Null hypothesis	Wald Statistic	P-value	Decision	Causality inference
ATO does not cause AGPI AGPI does not cause ATO	3.9062 0.1083	0.0190 0.8740	Reject D.N.R	Unidirectional (ATO to AGPI)
AES does not cause AGPI AGPI does not cause AES	1.9688 0.2240	0.1200 0.7545	D.N.R D.N.R	No causality
AIS does not cause AGPI AGPI does not cause AIS	0.8704 0.0357	0.3931 0.9750	D.N.R D.N.R	No causality
REER does not cause AGPI AGPI does not cause REER	3.2183 0.5580	0.0260 0.6210	Reject D.N.R	Unidirectional (REER to AGPI)
GRQ does not cause AGPI AGPI does not cause GRQ	1.4398 1.9158	0.0915 0.0635	Reject Reject	Bidirectional
EAC does not cause AGPI AGPI does not cause EAC	8.0160 1.9487	0.0030 0.2425	Reject D.N.R	Unidirectional (EAC to AGPI)
GCFA does not cause AGPI AGPI does not cause GCFA	0.4039 6.1497	0.7335 0.0070	D.N.R Reject	Unidirectional (GCFA to AGPI)
AGR_LAB does not cause AGPI AGPI does not cause AGR_LAB	0.3877 2.7763	0.6330 0.0455	D.N.R Reject	Unidirectional (AGPI to AGR_L

Table 3.18 indicates that that there is a uni-directional causal flow between agricultural productivity and openness. This was expected because when trade is liberalized, the volume of exports and imports increase. The removal barriers to trade increases the volume of trade thus leading to higher productivity. Increase in exports of agricultural products allows firms to gain from scale economies due to an expanded foreign market. Extra competition from exports of other countries increases the need to lower costs and embrace technological change which improves productivity. These results are consistent with those of Hassine and Kandil (2009) , Sunge and Ngepah (2020) and Xu et al., (2023). However, Abizadeh and Pardey (2009), while controlling for structural changes argued that trade openness does not have an effect on agricultural productivity.

Since their study focused on aggregate trade without considering the composition of trade, the conclusion that agricultural trade does not affect agricultural productivity may not be reliable.

The causality test results indicate that the share of exports and imports in agriculture have no causal relationships with agricultural productivity. According to endogenous theory, openness generates spillover effects and therefore improves knowledge flow. This is because increase in global trade facilitates acquisition of better technology, skills and human capital which contribute to higher productivity. The effects of learning by doing increases labour productivity and technology spillover due to accumulation of experience in the production process. While considering trade flows, agricultural imports may lead to competition which can depress prices of agricultural products. This may have a negative impact on agricultural productivity. However imports may lead to absorption of advanced technology (technology flow) as a result of imported products thus contributing to productivity growth. These findings are in tandem with those of Berger et al., (2021) and Xu et al. (2023).

There is a unidirectional causal flow between agricultural productivity and rate of exchange. The causality is unidirectional and runs from exchange rate to agricultural productivity. Exchange rates affect prices of agricultural commodities. A weaker exchange rate may lead to reduced earnings. Acquisition and purchase of farm inputs from foreign markets maybe significantly affected when the local currency is weak. Equally, agricultural export prices may be affected leading heavy losses by farmers. This can significantly affect agricultural productivity. Exchange rate fluctuations may discourage firms from venturing into investment, innovation and trade on agricultural commodities. Stability of the exchange rate is thefore necessary in order to improve agricultural productivity. These results are in agreement with those of Ani & Udeh (2021) and Lawal et al. (2016).

There is a bidirectional causal flow between agricultural productivity and government regulatory quality. This is an indication that feedback relationship exists between the two variables.. Enhanced institutional quality promotes enterprise, technological advancement and increases firm value. Good institutional quality can increase firm value by increasing enterprises total factor productivity. Institutional quality is significantly relevant in determining national competitiveness when reflected in economic growth and succesful development. An improvement in institutional quality may induce updgrading of the production system and technology thus contributing to gains in aggregate productivity. Private investment initiatives like R&D, access to markets and competition are promoted by policies and regulations. Institutionalization of such aspects improves the efficiency of production in agriculture. These results are consistent with those of Sunge & Ngepah (2020), Jung (2020) and Chang (2023).

There is a unidirectional causality between membership to the EAC and agricultural productivity. The causality runs from EAC membership to agricultural productivity. Economic integration facilitates transfer of skills through improved labour mobility which leads to productivity. The findings are in agreement with Olatunji (2019), Sunge and Ngepah (2020) and Mwangi et al. (2020). Trade barriers reduce the size of the market which may depress productivity. However liberalization expands the market for various agricultural goods leading to higher productivity. Regional integration improves efficiency of the market, promotes joint policy initiatives to boost agricultural productivity, have a building block for global integration, cost sharing of public goods or large infratructure projects like railways and irrigation. It also promotes non economic benefits like peace and security. Regional integration can help create value chains and increase productivity in agriculture.

Both capital formation and labour enjoy a unidirectional causality with agricultural productivity. In both cases, causality runs from agricultural productivity to agriculturalcapital formation and agricultural labour. Capital as a result of investment improves the quality equipment and tools which in turn enables farmers to improve the productivity in agriculture. This in turn leads to higher agricultural productivity. Additional or improved capital goods is intended to improve labour productivity by making farms more productive and efficient. Labour is a crucial input for agriculture. Various farm operations require access to steady and reliable pool of labour. Shortage of farm labour may lead to loss of earnings due to delays in various farm operations. It may also lead to unsustainable land management practices and cycles of environmental mismanagement. These may significantly affect agricultural productivity.

3.10 Robustness check on causality: Country Evidence

According to Dumitrescu & Hurlin (2012), due to the presence of heterogeneity in the panel, there might be causality in some countries but not in all of them. We therefore perform causality analysis at the individual country level for a robustness check on the full sample panel causality test results.

Table 3.19: Agricultural trade openness and Agricultural Productivity Nexus

H_0: Agricultural trade openness does not cause agricultural Productivity				H_0: Agricultural productivity does not cause agricultural trade openness			
Countries	Wald Statistic	p-value	Decision	Wald Statistic	p-value	Decision	Causality Inference
All	4.0669	0.0260	Reject	9.5629	0.878	D.N.R	Unidirectional
Burundi	22.424	0.742	D.N.R	0.0014	0.337	D.N.R	No causality
Kenya	18.069	0.023	Reject	-0.0180	0.051	Reject	Bidirectional
Rwanda	-58.764	0.007	Reject	-0.0053	0.036	Reject	Bidirectional
Tanzania	-11.717	0.399	D.N.R	-0.0025	0.612	D.N.R	No causality
Uganda	20.071	0.044	Reject	-0.0024	0.657	D.N.R	Unidirectional

By considering the panel as a unit in Table 3.19, a unidirectional causal flow exists between openness and agricultural productivity. The causality runs from trade openness to productivity. At individual country level, both Kenya and Rwanda enjoy a bidirectional causality between trade openness and agricultural productivity. This is a strong evidence of feedback relationship. However, in Uganda the causal relationship is unidirectional from openness to agricultural productivity. In Burundi and Tanzania, there is no evidence of causality. Therefore, we do not reject (D.N.R) the null hypothesis. According to Sunge and Ngepah (2020), the variations on the effects of openness on productivity across the EAC member countries may be attributed to two factors. Impact is determined by politics, depth and nature of individual countries signing and implementing measures geared towards the improvement of agricultural productivity in the region. The result may also be as a result of membership to more than one RTA. All the five EAC countries in the sample are members of both EAC and COMESA. In addition to being a member of the two RTAs, Tanzania is also member of SADC. This may lead to duplication or conflict of policies which may affect productivity.

Table 3.20: Agricultural Export share and Agricultural Productivity Nexus

H_0: Agricultural export share does not cause agricultural Productivity				H_0: Agricultural productivity does not cause agricultural export share			
Countries	Wald Statistic	p-value	Decision	Wald Statistic	p-value	Decision	Causality Inference
All	1.9688	0.1250	D.N.R	10.164	0.764	D.N.R	No causality
Burundi	7.8065	0.957	D.N.R	0.0015	0.056	Reject	Unidirectional
Kenya	61.974	0.014	Reject	-0.0037	0.283	D.N.R	Unidirectional
Rwanda	-46.558	0.130	D.N.R	-0.0009	0.149	D.N.R	D.N.R
Tanzania	-11.059	0.276	D.N.R	0.0012	0.683	D.N.R	D.N.R
Uganda	51.886	0.158	D.N.R	-0.0003	0.513	D.N.R	D.N.R

According to results presented in Table 3.20, the panel provides no evidence of causality between share of exports in agriculture and agricultural productivity. For specific country causality, there is evidence of unidirectional causal flow in Kenya and Burundi. In Kenya, the causality is running from agricultural export share to agricultural productivity while in Burundi, causality is running from agricultural productivity to agricultural export share. There is no evidence of causality in Rwanda, Uganda and Tanzania.

Table 3.21: Agricultural Import Share and Agricultural Productivity Nexus

H_0: Agricultural import share does not cause agricultural Productivity				H_0: Agricultural productivity does not cause agricultural import share			
Countries	Wald Statistic	p-value	Decision	Wald Statistic	p-value	Decision	Causality Inference
All	0.0357	0.9600	D.N.R	-0.8704	0.380	D.N.R	No causality
Burundi	-0.0054	0.785	D.N.R	5.8175	0.781	D.N.R	No causality
Kenya	0.0059	0.013	Reject	43.2509	0.891	D.N.R	Unidirectional
Rwanda	0.0025	0.892	D.N.R	-24.3526	0.622	D.N.R	No causality
Tanzania	0.0037	0.147	D.N.R	-132.757	0.410	D.N.R	No causality
Uganda	-0.0016	0.287	D.N.R	190.697	0.332	D.N.R	No causality

In Table 3.21 the panel provides no evidence of causal flow between import share and productivity. This result is consistent with causality results in Burundi, Rwanda, Uganda and Tanzania. However in Kenya, there is evidence of unidirectionl causal relationship from import share to agricultural productivity.

Table 3.22: Real Effective Exchange Rate and Agricultural Productivity Nexus

H_0: Real effective exchange rate does not cause agricultural Productivity				H_0: Agricultural productivity does not cause agricultural trade openness			
Countries	Wald Statistic	p-value	Decision	Wald Statistic	p-value	Decision	Causality Inference
All	3.2183	0.0013	Reject	0.5580	0.647	D.N.R	Unidirectional
Burundi	-0.1646	0.608	D.N.R	0.0119	0.965	D.N.R	No causality
Kenya	0.2299	0.317	D.N.R	0.5324	0.208	D.N.R	No causality
Rwanda	-0.3575	0.732	D.N.R	0.1846	0.118	D.N.R	No causality
Tanzania	0.2548	0.606	D.N.R	0.01205	0.944	D.N.R	No causality
Uganda	0.6319	0.010	Reject	0.1207	0.630	D.N.R	Unidirectional

Table 3.22 results provide evidence that Real effective exchange rate causes agricultural productivity, when the panel is considered a single unit. Causality tests at country level, provide evidence of no causality except in Uganda where a unidirectional causal flow exists between exchange rate and agricultural productivity. Like in the full panel, causality runs from real exchange rate to agricultural productivity.

Table 3.23: Government Regulatory Quality and Agricultural Productivity Nexus

H_0: Government Regulatory Quality does not cause agricultural Productivity				H_0: Agricultural productivity does not cause Government Regulatory Quality			
Countries	Wald Statistic	p-value	Decision	Wald Statistic	p-value	Decision	Causality Inference
All	1.4398	0.0750	Reject	1.9158	0.065	Reject	Bidirectional
Burundi	3.5048	0.326	D.N.R	0.03557	0.806	D.N.R	No causality
Kenya	-0.6916	0.364	D.N.R	-0.70690	0.003	Reject	Unidirectional
Rwanda	-0.9876	0.119	D.N.R	0.10679	0.734	D.N.R	No causality
Tanzania	-0.0221	0.998	D.N.R	-0.4667	0.084	Reject	Unidirectional
Uganda	0.9891	0.407	D.N.R	-0.0436	0.817	D.N.R	No causality

Results in Table 3.23 indicates that there is bidirectional causal flow between government regulatory quality and agricultural productivity. The causality runs from government regulatory quality to agricultural productivity when the panel is considered as a single unit. This is an indication of a strong evidence of feedback relationship. At the individual country level, Rwanda, Burundi and Uganda do not present any evidence of causality. However, in Kenya and Tanzania there is presence of unidirectional causality between government regulatory quality and productivity. In the two cases, causality is from productivity to government regulatory quality. The variation on the effects of reguatory quality on productivity may be due specific characteristics which are unique to each country. Weak regulatory quality may weaken the effect of trade openess on productivity. Strong regulatory framework can promote the benefits derived from open trade (Sunge&Ngepah, 2020; Florensa et al., 2015).

Table 3.24: EAC and Agricultural Productivity Nexus

H_0: Trade dummy does not cause agricultural Productivity				H_0: Agricultural productivity does not cause Trade dummy			
Countries	Wald Statistic	p-value	Decision	Wald Statistic	p-value	Decision	Causality Inference
All	15.681	0.0040	Reject	1.9487	0.242	D.N.R	Unidirectional
Burundi	1.3677	0.932	D.N.R	0.0034	0.918	D.N.R	No causality
Kenya	-1.9729	0.627	D.N.R	0.0147	0.009	Reject	Unidirectional
Rwanda	7.1785	0.470	D.N.R	0.0048	0.150	D.N.R	No causality
Tanzania	7.0619	0.285	D.N.R	-0.002	0.554	D.N.R	No causality
Uganda	20.909	0.000	Reject	0.0069	0.161	D.N.R	Unidirectional

In Table 3.24, there is unidirectional causal flow between membership to the EAC and agricultural productivity when the panel is considered as a single unit. The causality runs from membership to the EAC to agricultural productivity. Analysis of causality within individual countries shows no evidence of causality in Burundi, Rwanda and Tanzania. In Kenya and Uganda, the causality is unidirectional. In Kenya, the causality runs from agricultural productivity to EAC membership while in Uganda, causality runs from EAC membership to agricultural productivity.

Table 3.25: Agricultural labour and agricultural productivity nexus

H_0: Agricultural labour does not cause agricultural Productivity				H_0: Agricultural productivity does not cause Agricultural labour			
Countries	Wald Statistic	p-value	Decision	Wald Statistic	p-value	Decision	Causality Inference
All	11.014	0.653	D.N.R	23.426	0.0420	Reject	Unidirectional
Burundi	113.88	0.462	D.N.R	-0.0049	0.314	D.N.R	No causality
Kenya	-3.629	0.028	Reject	0.0214	0.562	D.N.R	Unidirectional
Rwanda	25.113	0.274	D.N.R	0.0278	0.632	D.N.R	No causality
Tanzania	-6.696	0.180	D.N.R	-0.0165	0.780	D.N.R	No causality
Uganda	-4.504	0.448	D.N.R	0.2231	0.020	D.N.R	No causality

According to the results presented in Table 3.25, a unidirectional causality runs between agricultural labour and productivity when the panel is considered as a single unit. The causality runs from agricultural labour to agricultural productivity. Individual country causality analysis provides no evidence of causality in Burundi, Rwanda, Uganda and Tanzania. However, in Kenya the causality runs from productivity to agricultural labour.

Table 3.26: Agricultural capital and Agricultural productivity nexus

H_0: Agricultural capital does not cause agricultural Productivity				H_0: Agricultural productivity does not cause agricultural capital			
Countries	Wald Statistic	p-value	Decision	Wald Statistic	p-value	Decision	Causality Inference
All	0.7991	0.7400	D.N.R	5.768	0.013	Reject	Unidirectional
Burundi	-0.0274	0.963	D.N.R	0.0501	0.169	D.N.R	No causality
Kenya	-0.0219	0.949	D.N.R	0.1280	0.001	Reject	Unidirectional
Rwanda	0.1173	0.794	D.N.R	0.0531	0.015	Reject	Unidirectional
Tanzania	0.4581	0.098	Reject	0.0660	0.205	D.N.R	Unidirectional
Uganda	-0.2049	0.349	D.N.R	-0.320	0.073	Reject	Unidirectional

By considering the panel as a single unit, Table 3.26 shows a unidirectional causal relationship between agricultural capital and productivity. The causality runs from productivity to agricultural capital. In Burundi, there is no evidence of causality. In Kenya, Rwanda and Uganda, the causality is unidirectional and running from agricultural productivity to agricultural capital. In Tanzania, the causality is also unidirectional but running from agricultural capital to agricultural productivity.

3.11 Summary and Conclusions

The study analyzed the effect of agricultural trade openness on agricultural productivity. Variables were both cointegrated and I(1). After controlling for heteroscedasticity and autocorrelation, results revealed that panels were homoscedastic with no autocorrelation. Tests for cross sectional dependence indicated a strong CSD in the panel. Long run panel estimation results showed that agricultural trade openness, government regulatory quality, membership to the EAC and agricultural labour positively influenced agricultural productivity. Agricultural export share negatively influenced agricultural productivity while the effect of agricultural import share was insignificant. The direction of causality was evaluated using Dumitrescu & Hurlin (2012) Granger causality approach. Pairwise panel granger causality tests revealed unidirectional causal flows between productivity and openness, exchange rate, EAC membership, capital formation and labour. Agricultural productivity and government regulatory quality had a bidirectional causal relationship. Granger causality tests have shown that a change in agricultural productivity is preceded by changes in trade openness, exchange rate, regulatory quality and trade dummy. Agricultural productivity then influences changes in agricultural labour and capital formation.

Two main findings can be drawn from this study. First, trade openness and membership to the EAC are significantly influence agricultural productivity. This could be due to competition, innovation and technology absorption in the local market which contributes to growth in productivity. Regulatory quality positively influences productivity. Government regulation and policies shape the business environment through their impacts on costs, risks and barriers to competition. Low levels of agricultural productivity can trigger policy review and adjustment leading to zero rating of agricultural inputs, tax incentives to farmers and provision of subsidies. Such initiatives may promote agricultural productivity. The other finding is that trade openness and membership to the EAC are significant determinants of agricultural productivity. This may be as a result of increase in competition, innovation and technology absorption in the local market which may contribute to growth in productivity.

3.12 Policy Implications

The study has provided evidence that trade openness can influence agricultural productivity. The implication of this outcome is that, the agricultural sector requires increased trade liberalization to expand markets for agricultural products and boost productivity in the sector. EAC trade policies should be reviewed to improve its operational efficiency and increase the volume of trade. The EAC leadership should devise strategies to attract more members in order to expand the EAC regional market. Existing trade barriers which are an impediment to free trade should be removed to enable the countries enjoy wide ranging effects of trade openness.

3.13 Limitations of the study

The membership of the EAC has seven countries. This study used five member countries because the other two countries joined the community recently and therefore their data set could not fit into the time frame and scope this study. Agricultural Research and Development is key determinant of productivity. This study lacked necessary data on agricultural research and development to allow for its inclusion in the estimation process.

3.14 Areas for Further Research

The study analyzed the effect of agricultural trade on agricultural productivity. Future studies may analyze how agricultural exports affect agricultural productivity. Role of agricultural imports on the sector's productivity may require further analysis. The role of trade openness on productivity of specific crops and livestock varieties could also be considered in future studies. The study was done in the EAC which is just one of the RTAs in SSA. Comparative studies between the EAC and other RTAs may be topics for further investigation. The effects of membership to more than RTA on agricultural productivity can also be investigated.

CHAPTER FOUR

AGRICULTURAL FINANCING AND AGRICULTURAL PRODUCTIVITY GROWTH IN THE EAST AFRICAN COMMUNITY

4.1 Background of the study

In many developing countries, large numbers of their populations live in rural areas which are characterized by high poverty levels. Majority of the rural populations mainly depend on agriculture which is the main source of livelihood. This is a clear indication that agriculture is an important determinant of growth (Diao & Dorosh, 2007). Agriculture was viewed in the traditional economy as the main channel for producing food and industrial raw materials. The transformation of traditional agriculture using new technology into a vibrant modern sector has proved that agriculture is capable of promoting growth and influencing development (Adelman, 2001).

The level of development among countries contributes to the variation in the relationship between agricultural finance and output. The contribution of increased investment and development of agriculture on growth of economies has been proven through the results of agricultural revolutions in Europe, America and Asia. An increase in agricultural investment levels will reduce food insecurity and poverty while promoting growth (World Bank, 2013). The increase of poverty in Africa, makes it important to explore the poverty reduction power of agriculture by enhancing investments in the sector (IFAD, 2013).

In economic theory, the financial sector assists in channeling capital to most productive ventures which facilitate the achievement of enhanced developent. Improved efficiency of institutions dealing with financial matters enhances the establishment and creation of financial sector stability (Schumpeter, 1912). The financial sector ensures sustainability of economic growth since a healthy financial sector not only assists in expediting financial transactions, but also makes financial institutions to be more efficient which contributes to economic growth (Mohsin & Abdelhak, 2003).

Efficiency of the financial sector is achieved through sustained growth and expansion. An efficient financial sector may mitigate investment risk, ensure liquidity and accelerate long term investment in the economy (Ayyagari, Asli, & Vojislav, 2006). The banking sector enhances economic growth through provision of external financing, financial system liquidity and acceleration of capital accumulation by easing the financial intermediation process (Abubakar & Gani, 2013). Financial intermediation ensures resources are efficiently allocated in the economy by linking surplus and deficit units with the help of efficient financial institutions. This efficiency promotes the process of financial intermediation which may lead to long run financial stability in an economy (Benhabib & Spiegel, 2000).

The level of productivity in agriculture among the less developed countries is very low which compares poorly with other sectors like manufacturing, mining and the service sector. The contribution of agriculture in the promotion of growth in underdeveloped countries is supported by evidence that improvements in agriculture GDP has proved to be an effective strategy of reducing poverty levels in comparison to other sectors within an economy (World Bank, 2007a).

4.1.1 Overview of Agricultural Finance

Agricultural finance includes public or private financial resources which are channeled to the sector to enhance its development and productivity growth (Yazdani, 2008). In addition to government financial allocation to the sector, agricultural finance also includes funds provided by NGOs towards promotion of community and sector development agenda, reduction of income inequality and improvement of rural development (Soheila & Bahman, 2013). The common challenges facing agriculture in all the EAC partner states include low productivity levels in crops and livestock, losses due to poor storage facilities and mismanagement of natural resources which increase risks attributed to climate change. The problems are due to various constraints; no investment in research and development, weaknesses in the capacity of institutions in the agricultural sector, failure to apply modern technology, poor policies and poor response to emergencies (EAC, 2019).

The EAC Council of Ministers in 2019 approved the EAC Regional Agriculture Investment Plan (RAIP), 2018 – 2025. The plan has interventions to achieve Maputo (2003) and Malabo 2014 declarations. The Comprehensive African Agriculture Development Programme (CAADP) was aimed at allocating 10% of the annual budget to agriculture and achievement of annual 6% growth in agricultural GDP for each member country amongst other targets. Despite these interventions, food deficits are still prevalent in the EAC (state of hunger varying across member states) and remain above the world average (EAC, 2019).

The average share of agriculture in government expenditures within the EAC was 5.1% between 2001 and 2020. The Agricultural Orientation Index (AOI) for the same period was 0.156 (FAO, 2022). The low allocation to the sector is partly attributed to reliance on donor funding. Between 2017 – 2020 development partners funded 90% of the agricultural sector budget in the region (EAC, 2021).

Farmer's financial resources are normally limited which constrains their capacity to improve productivity growth. Agricultural value chain has several actors which include dealers in inputs, buyers, traders, transporters and processors who all have various financial needs. If there is limited or lack of access to financial services, value chain actors may incur losses that may affect agricultural productivity growth. Provision of financial services is therefore necessary at various stages of the agricultural production value chain (Sarker, 2016).

4.1.2 The role of Agricultural finance in the EAC

Low levels of financial access have constrained the capacity small scale farmers who are the majority in the EAC to make significant investment in agriculture. This has resulted to low productivity and non-optimal use of farm resources. Financial constraints have prevented many farmers and other agricultural value chain actors from expanding their agricultural production capacities. Financing is crucial in the agricultural value chain. Availability of finance expands a farmer's working capital from which they can buy farm equipment and other requirements necessary in productivity improvement (AfDB, 2016). There is also improved accessibility to produce markets, capital markets for agro-processing and market information. This results in commercialization of agricultural production which enable farmers to get better returns.

The main sources of agricultural financing in the EAC include; public resources (government expenditure), sovereign wealth bonds, non-foreign investment, funding from donors, private equity finance which includes FDI and domestic savings as well as investments. External private equity finance involves trade and capital flows (FDI) while internal private equity finance is composed of domestic savings and investments. FDI has significantly increased private funding in the agriculture value chains. It also brings on board managerial skills, market linkages and technological transfer. State run models for agricultural face a lot challenges due to various interest and corruption. However, community financing models have played an important role in agricultural financing. Producer co-operatives and Sacco's have remained significant suppliers of agricultural credit. Private participation in agricultural financing has been growing. Credit provision to small holder farmers using agribusiness companies and exporters of various agricultural products have been making good progress (EAC, 2018). In the EAC, donor agencies and NGOs have been active in agricultural micro finance activities. Some Micro-Finance institutions in the region are associated with donors and NGOs both directly and indirectly.

4.1.3 Models of Agricultural Financing in the EAC

Agricultural financing in the EAC is implemented using various models.

Asset Financing Model: The method mainly focuses on the financing of specific agribusiness assets that will enhance medium and long term productivity growth among small holder farmers. Through asset financing, small scale farmers are able to access assets such as tractors, irrigation systems for irrigation, farm equipment and breeding stock among others. Some of these assets assist in income generation for the farmers.

Micro-Leasing Model: There is no major difference between this model and asset financing. In this case, a farmer acquires an asset but ownership is not transferred until the asset if fully paid for. This is also referred to as operational lease which is normally long term rental contract.

Group Based/Member Based Financing Models: In this model, farmers organize themselves into groups to enable them access various financial opportunities. The initiative is driven and controlled by the farmers. It allows members of the group to collectively market their products even though there might be differences in their farm assets. The main strength of this strategy is that it allows small scale producer organizations to work together in order to improve their participation in emerging markets. Through this method, negotiation skills of the members are improved and this results in better service provision.

Out-grower Schemes/Contract farming: The method is similar to group based financing. In this case, a company contracts a group of farmers and gives out credit facilities to facilitate production. The company acts as a Micro-Finance Institution (MFI) giving credit to farmers.

Warehouse receipt system: The method is mainly common in grain producing regions. It is mainly applicable to agricultural commodities such as grain, coffee, cotton that can be stored for some time before sale. Goods are stored in safe custody on behalf of the depositors. For a farmer to access credit from a financial institution, the warehouse acts as the collateral for credit.

Value chain financing: The model uses the networks of agents involved in the value chain. The members regularly share information on their businesses which helps to mitigate risks. Credit is therefore provided through the value chain. The method is very popular with suppliers of inputs.

Credit Voucher System: In this model, farmers access agricultural inputs on credit using cash and a credit voucher system that is staggered. This assists in the reduction of credit diversion to other needs. The credit voucher is used to disburse seventy-five percent of the credit and the remainder through a cash voucher. The model involves several actors. There is a Savings and Credit co-operative from which members draw their membership through shares. A MFI that manages the Sacco; Inputs dealers from which farmers redeem their vouchers, government where necessary and applicable and a donor who provides guarantee to pay the loan in case of default.

Index Based Insurance: Small scale farmers are generally exposed to various risks. Even though weather and other natural aspects are the main causes, risks attributed to markets and prices on inputs and output are also a major challenge. In general, agricultural insurance which may provide cover for various risks including theft, death of animals and crop destruction is normally very expensive. It involves payment to farmers which is triggered when the threshold for a risk indicator breached.

Other agricultural financing models include agricultural factory and trade receivable finance; credit guarantee; price smoothing and value chain intermediation.

4.2 Problem Statement

The emergence of new and modern technologies in agriculture has enhanced the role and significance of financing on agricultural production. Traditional agriculture has undergone several transformations in the recent past. Modernization of agriculture is essential in improving its productivity growth. However, the acquisition of modern technologies to improve productivity increases the financial needs of farmers. The process of modernizing and commercializing agriculture requires investment in capital, labour, technology, research and development and marketing. Low levels of productivity in agriculture results in low incomes to farmers and cumulatively slows growth in countries where agriculture is the most reliable indicator of growth.

Growth of incomes alongside rapid urbanization in SSA has led to the expansion of food markets. Inaccessibility of financing by smallholder farmers has been a barrier to those seeking to transition from subsistence to commercial agriculture. Climate change dynamics have increased the need for investments to make agriculture resilient to shocks. Rural infrastructure is still poor and this affects accessibility to markets thus making farmers to suffer huge losses.

The percentage of agricultural land in the EAC under irrigation is below ten per cent even though there is a lot of potential to boost agricultural production through irrigation. Despite these challenges, agriculture still remains the main source of livelihood in the region. To address these challenges and enhance agricultural productivity growth in the EAC, financing and investment shortcomings in agriculture require urgent attention. If agricultural financing issues are not quickly resolved, gains already made in growth of rural areas and poverty eradication may be wiped out. Climate change, population expansion, changing dietary habits, global pandemics and conflicts pose challenges to agricultural production. As a result of these challenges, policy makers must create a resilient and sustainable agricultural sector. This requires adequate investment in the sector to boost its productivity growth.

4.3 Research questions

The general research question of the study is; what is the effect of agricultural financing on agricultural productivity growth in the EAC? The specific research questions will be:

(i) What is the effect of agricultural credit on agricultural productivity growth?

(ii) What is the contribution of government agriculture sector expenditure on agricultural productivity growth?

(iii) What is the causal flow between financing and growth in agricultural productivity?

4.4 Objectives of the Study

The main study objective is to analyze the effect of agricultural financing on agricultural productivity growth in the EAC. The specific objectives will be to:

(i) Analyze the effect of agricultural credit on agricultural growth.

(ii) Examine the contribution of government agriculture sector expenditure on agricultural productivity growth.

(iii) Estimate the causal flow between agricultural productivity growth and agricultural financing?

4.5 Justification of the Study

In LDCs, agriculture drives economic growth and contributes to improved performance of other sectors (Olena, 2017). Agricultural sector in developing countries is assumed to be large enough to spur growth and development in such countries (World Bank, 1989).The high risks associated with agricultural production has made many financial institutions to set stringent conditions which make it difficult for firms involved in agriculture especially the small holder farmers to get accessible and affordable credit. This has made the informal financial sector to emerge and complement the public sector in agricultural financing.

The slow growth of agricultural output in EAC is attributed to low levels of agricultural investment in the continent. The need for agricultural financing is influenced by the following factors; First, farming is a seasonal activity which makes incomes of farmers to be unstable and seasonal; Secondly, finance is required to meet labour costs; Thirdly, acquisition of modern storage and preservation methods can enable farmers to hold stock as they conduct market surveys; Fourthly, servicing of capital equipment and purchasing of inputs require financial resources. Agricultural financing is required in the development of infrastructure to allow free movements of agricultural inputs and outputs.

To improve growth of productivity in agriculture, the sector must be made demand driven. Investment in value addition on agricultural products is important in enhancing competitive advantage so as to maximize opportunities in domestic and global markets. There must be sustained growth and expansion of agricultural output. To achieve this goal, much interest is given to the contribution of agricultural financing in promoting productivity growth in agriculture. Past studies have shown that Africa can easily achieve the SDG targets by accelerating agricultural productivity.

4.6 Literature Review

This section reviews theoretical and empirical literature. It also presents an overview of the reviewed literature.

4.6.1Theoretical Literature Review

There are various opinions explaining the contribution of finance on growth. The financial sector was instrumental in facilitating and mobilizing capital for production during industrial revolution in England (Bahegot, 1873; Hicks, 1969). An efficient system of banking may promote innovation by identifying and providing funds to entrepreneurs with better innovative ideas (Schumpeter, 1912).

The cause of lower growth rates in the less developed and transition economies was underdevelopment of the financial system (Mishkin, 2003). The argument was supported by Duican & Pop (2015) who proposed that achievement of higher growth rates in a country required a stable and efficient financial sector. Studies on how the financial sector affects growth have a common argument that the development of the market for credit promotes growth through increased accumulation of capital and adoption of new technology (Levine, 1997).

Economists agree that financial sector growth has the following advantages; enhances growth by allocating resources to productive investment, leads to reduction in costs of generating information and allows risk management experts to devise ways of financing innovations and risky investments which are productive (Saida & Frikha, 2016). The linkage between credit and growth in agriculture is also supported by the concept of returns to scale. It explains how output responds to proportional changes among the input variables. It states that; a proportional variation in input amounts applied in production process results in a specific change of output behaviour. Public investment in agriculture, farm roads in rural areas and irrigation positively contribute to enhanced productivity in agriculture. Micro credit provided by the government through various schemes improves the welfare of poor farmers (Li & Gan, 2011). Investment in health services and education of farmers can also enhance growth of agriculture.

Improvements in agricultural productivity growth require the availability of vibrant financial sector which can meet the financial requirements of farmers by enabling easier accessibility. In an initiative to implement the proposal, the African Development Bank designed strategies to partner with the informal rural finance institutions in order to build their capacity with the aim of mobilizing domestic savings and promoting the provision of effective and efficient credit facilities in the rural areas. The move was aimed at stimulating and boosting agricultural production mainly among the small holder farmers (ADB, 2000).

A strong and efficient financial sector stimulates growth by boosting the rate of savings and investment which then increases the physical capital accumulation. Development of the financial sector fosters efficiency by stimulating innovative activities and strengthening competition

(Darrat, 1999). Various innovations in the financial system lead to improved efficiency in transfer of funds. Improved accessibility of services provided by the financial sector reduces constraints that have prevented the poor from participating in various economic activities. Access to financing promotes development of technology because new knowledge is created through availability of financing which provides an incentive for creative innovative thinking (Calderon & Liu, 2003).

4.6.1.1 Models of Financial Sector Development

Three models explain how financial sector development affects growth and development. The models include; asymmetric information model, structuralist/neo-structuralist model and McKinnon Shaw model.

The asymmetric information model is based on information asymmetry and costly information generation in financial markets. The model assumes that financial contracts enforcement and monitoring are costly (Montiel, 2003). A situation in which information asymmetry exists may make the process of intermediation in financial markets to be expensive to businesses. This is because of high expenditure amounts since market agents will have to overcome adverse selection as well as principal – agent problems. Financial markets failure arising from financial contracts failure, negatively affect the growth of financial institutions.

Government intervention through regulation is necessary to reduce or eliminate asymmetries, uncertainties and high transaction costs. State intervention therefore enhances financial development. The interdependence between the financial sector and fiscal/monetary policies are often embodied in financial regulations. The growth in financial innovation and financial services products has a positive influence on financial development (Bojanic, 2012). Though information asymmetry may be prevalent in most economies, the model tends to explain the problems experienced by underdeveloped economies due to low levels of financial development. Farmers and agricultural value chain actors should have adequate information about various funding options available in the region. This will promote and increase the number farmers seeking agricultural funds for further investment in agricultural production. The flow of information on funding opportunities for agricultural production is very low in the EAC region. This affects the initiatives to increase investments in agriculture.

The structuralist/neo-structuralist model works under the assumption that there exists non-institutional finance which is expressed in the form of indigenous banking and lending of money. The contribution of informal financial sector on rate of growth is recognized by the model. The model further explains that financial sector dualism is a significant indicator of expansion and growth. According to this model, there is a belief that the existence of stable macroeconomic policies enhances financial sector growth and development. The model predicted that growth rate of the financial sector is influenced by the level of economic progress (Murinde & Eng, 1994a) . In the EAC, there are various informal sources of financing which act as a major of agricultural finance for mainly small scale farmers. To improve their operational efficiency, there is need for proper regulatory framework to avoid exploitation of farmers.

The McKinnon Shaw model explains restrictions in the growth of financial sector. The model proposes that repressive policies discourage financial sector development like improvements in the growth rates of private bonds and equity markets. Repression of the financial sector retards its financial deepening and slows down growth. To enhance the achievement of higher rates of growth and development, the model advocates that the financial sector should be liberalized. The model further advocates against interest rate ceilings and caps because they slow down the general operations of an economy (McKinnon, 1973; Shaw 1973). Due to its nature, agricultural production is vulnerable to several risks which may affect its performance. The EAC governments should liberalize the financial sector to enhance financial inclusion. This will make agricultural finance to be affordable and accessible.

4.6.1.2 Supply leading and Demand following hypotheses

According to Jung (1986) the relationship between advancements in the finance and levels of growth remained unresolved. This suggestion was made after Patrick (1966) explained that supply leading and demand following theories are useful and relevant in explaining the relationship between the two concepts (Jung, 1986).

Supply leading hypothesis

The hypothesis explains that when the financial sector grows and develops, it affects the growth rate of a nation. According to the hypothesis, activities undertaken by financial institutions stimulate increase and growth of the productive activities in a country. The implication is that higher demand for institutions and their services influences the establishment of such institutions to offer those services. The provision of such services increases their demand by investors thus contributing to growth of an economy (Odhiambo, 2008). The intermediation function by formal and informal financial institutions towards agriculture and other sectors by offering financial services determine the productivity of any given sector.

Demand following hypothesis

The hypothesis explains that real growth generates higher demand for services offered by financial institutions. Robinson (1952) supported the hypothesis by using the argument, where "venture drives, finance follows" and further argued that as the financial sector grows and develops, it is mainly a response to growing demand for services offered by financial institutions due to enhanced growth. The general belief in demand following theory is supported by the money demand theory developed by Friedman & Schwartz (1963) and Demetriades & Hussein (1996). The opinion was justified by the argument that a larger proportion of financial development is the transposed velocity of money stock in circulation which treats services offered by money balances in an economy to be unnecessary. Therefore, any progressive contribution of real GDP per capita on the financial sector may produce an elasticity of income higher than unity. Therefore, money demand influences causality from real GDP to growth of financial sector (Ajayi, Nageri, & Akolo, 2017).

4.6.1.3 Neutrality Hypothesis

The monetary policy affects the economy through the its transmission mechanism. The response of macroeconomic variables to adjustments in monetary policy can be investigated by examining how the variables respond to variations in money supply. This may help to assess the efficiency of monetary policy. Various monetary economists have argued that injecting additional money into the macro economy has a neutral effect. The response of real variables like employment and economic growth to t money supply explains how the neutrality hypothesis works. Using the "quantity theory of money", the neutrality hypothesis attempts to explain if money supply changes affect macroeconomic variables. The hypothesis states that the behaviour of real variables is independent from long run money supply changes. Money supply changes mainly affect nominal variables while real variables are not affected (Tawadros, 2007). Super neutrality hypothesis explains that the real economy remains unaffected by changes in money supply because such changes do not affect real variables. Even though neutrality hypothesis of money may exist in the short term, it is expected to be invalid in the long term due to sticky market prices (Moosa, 1997).

4.6.2 Empirical Literature Review

Nawaz (2011) examined how credit advanced to the agricultural sector affected agricultural productivity in Pakistan from 1974 - 2008. Agricultural credit was used as an indirect input. The effect of credit was significant in facilitating the acquisition of new and modern farm technology, farm inputs and conducting research. Allocation of credit to agriculture influenced growth of productivity agriculture.

Chisasa & Makina (2013) empirically assessed the effects of credit provision by banks affected productivity of agriculture in South Africa from 1970 – 2009. The main variables were; output in agriculture (dependent variable), credit provided by banks, capital, labour and amount of rainfall. Estimating of the Cobb – Douglas (C-D) production function was done using OLS. The estimation results indicated that the credit provided by banks was a positively significant determinant of productivity in agriculture.

Dhrifi (2014) examined how the financial sector growth affected productivity in agriculture in 44 African nations between 1990 - 2012. The GMM system estimator to analyze how growth of the financial sector influenced productivity of agriculture. It was found that the financial sector alone could not spur productivity growth in agriculture. Existence of quality institutions alongside financial sector development contributed to agricultural productivity growth.

Agbada (2015) assessed how agricultural financing affected the level of agricultural output in Nigeria. Multiple regression techniques were used in the estimation of results. Agricultural Credit Guarantee Scheme (ACGS) and government secured loans were used to represent agricultural financing while output was represented by GDP of agricultural production. There was a positive contribution of ACGS on growth of output in agriculture. Agricultural financing positively enhanced output growth in agriculture.

Sarker (2016) assessed how agricultural financing by banks affected agricultural productivity in Bangladesh. Using a simple linear regression model, there was a strong correlation between agricultural financing from the banking sectors and growth of productivity in agriculture. The estimation results showed that credits advanced by the banking sector were significant in facilitating financial inclusion. There were increased investments in agriculture which promoted growth in productivity.

Hassan (2017) examined how loans channeled to agriculture affected the volume of output in Pakistan from 1981 – 2015. The total loans channeled to agriculture and broad money (M3) to GDP ratio were the main variables. An estimation using VAR model revealed significant positive influence of agricultural credit disbursement, agricultural capital formation and financial sector liquidity on agricultural productivity growth. Agricultural farm credit disbursement was used as a key indicator of access to agricultural financing.

Onoja (2017) analyzed how financial sector development contributed to growth of agricultural productivity among 75 underdeveloped economies. The study was designed to investigate the concerns about falling levels of agricultural productivity which were attributed to financial exclusion in the sector and thus contributed low levels of agricultural investment. There was no effect of financial sector growth on agricultural productivity. The effect of agricultural credit was positive and significant in all countries in the sample. However, among the developed economies, its effect was positive but insignificant.

Oluwafemi & Omenka (2018) analyzed the contribution of credit on agricultural productivity in Nigeria (1987 – 2016). Multivariate OLS regression model and Johansen cointegration test were used for estimation. The results indicated that credits advanced by commercial banks to agriculture had a long term effect towards the improvement of productivity.

Shabir et al (2020) analyzed the role of agricultural credit on productivity of cereals in Punjab region of Pakistan. The study used a C-D production function in modelling the relationship between variables. Results showed that credit influenced the productivity of wheat. The study recommended expansion of credit facilities exclusively for farmers. Credit restrictions should be reduced so that small holder farmers can easily obtain agricultural loans.

Chaiya et al (2023) analyzed the role of credit on farm productivity in Khyber Pakhtunkhwa region of Pakistan. Analysis was done using ANOVA and Multiple Regression Analysis. Results indicated that agricultural credit enhanced crop production. However, proportions of agricultural credit were used on health care, children education, domestic needs and businesses. The regression model results indicated that farmer's age, experience, farm size, farm income, farm labour and ownership were the main determinants of the amount of agricultural credit. The paper recommended that policy measures should developed to stop use of agricultural credit on domestic needs.

4.6.3 Overview of literature

Empirical literature shows that agricultural finance is an important determinant of agricultural productivity. These studies mainly focused on agricultural credit as a source of agricultural finance. However, there are other channels of agricultural financing which include; government financial allocation to agriculture, FDI to agriculture, Official Direct Assistance (ODA) to agriculture and private sector credit among others. The financial system also requires the support of quality institutions to achieve efficiency and effectiveness. This necessitates the inclusion of institutional quality variables in the analysis which is missing in many previous studies. The macroeconomic environment is regulated by various policies which justifies the inclusion of institutional quality.

Broad access of financial services is important because it allows the poor and those without collateral to acquire finances for agricultural investment. Lack of financing may prevent entry of new and innovative firms from venturing into agricultural production. Access to agricultural financing enables the acquisition of new and modern technology which may stimulate productivity growth in agriculture. Availability of financing can also promote creativity and innovation in designing new strategies to improve productivity. The reviewed studies did not control for cross sectional heterogeneity and cross sectional dependence which could lead to biased and inconsistent estimation results.

4.7 Methodology

This section explains the theoretical framework, specifies the empirical model to be estimated, various diagnostic tests, measurement and description of variables and sources of data.

4.7.1 Theoretical Framework

The neo classical growth model (Solow, 1956) is applied in testing how agricultural financing affects agricultural productivity growth. The neo classical production function is specified using capital and labour:

$$Y_t = f(L_t, K_t) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4.1)$$

Where Y is the output, L is labour and K is capital. The study seeks to derive a growth equation to explore how agricultural financing affects growth of agricultural productivity. The model is extended to include various agricultural financing variables.

Agricultural Productivity Growth = f (Agricultural Credit, Government Agricultural Sector Expenditure, Private sector credit, Agricultural Foreign Direct Investment, Official Direct Assistance to Agriculture, Gross Domestic Savings, Government Efficiency, Capital Formation in Agriculture, Agricultural Labour)

The growth model was extended by (Barro, 1991) to include economic and structural coherence variables. The growth model was further extended by including non-farm labour, level of education and expenditures on health (Humphries & Knowles, 1998).

4.7.2 Empirical Model Specification

Following Nor & Elya (2016), Lee & Chang (2009) the role of financing on agricultural productivity growth is modeled as;

$$AGR\_PG_{it} = f(AGRCR_{it}, GFCF_{it}, PRVCR_{it,} AGRFDI_{it}, GCF_{it}, AGRODA_{it}, GS_{it}, GVEFF_{it}, AGR_{LABOUR_{it}})$$

$$AGR\_PG_{it} = \alpha_0 + \alpha_{1i} AGRCR_{it} + \alpha_{2i} GFCF_{it} + \alpha_{3i}\, PRVCR_{it} + \alpha_{4i}\, AGRFDI_{it} + \alpha_{5i} GCF_{it} + \alpha_{6i} AGRODA_{it} + \alpha_{7i}\, GSAV_{it} + \alpha_{8i} GVEFF_{it} + AGR\_LABOUR_{it} + \mu_i \quad \ldots\ldots\ldots\ldots\ldots \text{(4.2)}$$

In the above equation, the subscript **i** ($\mathbf{i = 1, 2, \ldots, N}$) is the cross sections, subscript $\boldsymbol{t}$ ($\boldsymbol{t = 1, 2, \ldots, T}$) is the time period, $\boldsymbol{\alpha_0}$ is the country specific effect and μ is the disturbance term.

AGR_PG is the agricultural productivity growth

$AGRCR$ is the agricultural credit

$GFCF$ is government agricultural sector expenditure

$PVCR$ is the private sector credit

$AGRFDI$ is the agricultural Foreign Direct Investment

GCF is the gross capital formation in agriculture

$AGRODA$ is the Official Direct Assistance to agriculture

$GSAV$ is the gross domestic savings

$GVEFF$ is the government efficiency

AGR_LABOUR is the agricultural labour

4.7.2 Model Estimation

The estimation procedure involves six different steps. We test for stationarity of variables. Cointegration, slope homogeneity, autocorrelation, CSD, Panel Auto-Regressive Distributed Lag (Panel ARDL) and Granger causality test.

4.7.2.1 Panel Unit Root Test

The test is used to confirm if unit roots are present in panel data. The tests include; LLC (2002), IPS (2003) and Breitung (2000) unit root tests. LLC (2002) & Breitung (2000) tests make the assumption of homogeneity for all members of a panel in the dynamics of the autoregressive coefficients. In this study IPS (2003) test for unit roots is applied because it allows for the existence of various autoregressive parameters among members of a panel and the short run dynamics under the alternative that there is a stationary trend. For robustness, we test for panel unit roots using the three tests.

4.7.2.2 Panel Cointegration test

The test is performed using Pedroni (2004) technique. The methodology allows for testing of long run equilibrium within multivariate panels while dynamic and long run cointegrating vectors remain heterogeneous across individual members. Pedroni's cointegrating regression is expressed as:

$$y_{it} = \alpha_i + \delta_i t + \beta_i X_{it} + e_{i,t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4.4)}$$

Where for each panel member i, X_{it} and β_i are m - dimensional column vector and row vectors respectively. The parameters α_i and δ_i allow for member specific trend and deterministic trends. The coefficients of slopes β_is are allowed to vary across individuals so that vectors of cointegration may be heterogeneous across members of a panel (Sabuj & Madheswaran, 2010). For robustness of the test, the analysis also includes Kao (2000) & Westerlund (2007) cointegration tests.

4.7.2.3 Slope Homogeneity Test

The test is done using Pesaran and Yamagata (2008) test. Under the null hypothesis, there is homogeneity of slope coefficients across cross sectional units and in the alternative, they are heterogeneous. Failure to test and control for heterogeneity of the slopes can lead to biased results. Therefore, the question as to whether the assumption on slope homogeneity holds requires clarification before addressing the underlying empirical question (Bersvendsen & Ditzen, 2021). Weighting is done by standard errors for each unit which allows for heteroskedasticity of the residuals. The test was extended by Blomquist and Westerlund (2013) to include a heteroskedasticity and autocorrelation consistent (HAC) robust version.

4.7.2.4 Test for Autocorrelation

The existence of serial correlation may lead to biased standard errors in models for panel data which may affect the efficiency of results. Testing for the existence of serial correlation in the model for panel dataset is therefore considered to be necessary (Drukker, 2003).

4.7.2.5 Test for Multicollinearity

Multicollinearity arises when two or more independent variables are correlated. The existence of such a correlation complicates the process of determining the effect of regressors on the response variable. Due to the nature of our independent variables, agricultural trade openness, agricultural export share and agricultural import share, it is necessary to do the test. The Variance Inflation Factor (VIF) is used in the estimation.

4.7.2.6 Cross Sectional Dependence (CSD) Test

Another common cause of bias in panel data is cross sectional dependence attributed transmission of shocks between countries. This is due to high level of trade and integration due to globalization among countries (Mwangi et al. 2020). We test for CSD using the Pesaran (2021) weak CSD test. The null hypothesis of the test is a weak CSD with the alternative being strong CSD. Failure to account for CSD due to correlation between common factors and explanatory variables may result in an omitted variable bias. This can lead to biased and inconsistent estimates.

4.7.2.7 Panel ARDL Estimation

The panel auto regressive distributed lag model (ARDL) is applied in analyzing the effects of agricultural financing on agricultural productivity growth. The estimation method has three estimators; Pooled Mean Group (PMG), Mean Group (MG) and Dynamic Fixed Effects (DFE) estimator. The main weakness of the three tests is that they make an assumption of cross sectional independence. Cross country data are normally characterized by CSD. The implication is that a common factor shared by cross section units which affects all of them in different ways. Failure to consider and control for the dependence may lead to bias and inconsistency of results. In this study, we use a recent methodology called Panel Cross sectional ARDL (CS- ARDL) developed by Ditzen (2021). The main advantage of this method is that it is cross- sectional augmented. This improves its efficiency in estimating data characterized by cross sectional heterogeneity and cross sectional dependence.

4.7.2.8 Panel Granger causality test

When dealing with data consisting of many time series dimensions like the case of panel data, Granger causality is an efficient and useful tool in the analysis of causality between variables. Pairwise granger causality tests developed by Xiao et al. (2023) is applied in the study. It is the latest technique for testing granger causality in literature. The strength of this approach is that under the null hypothesis, all the parameters of Granger causality are zero which makes them to be homogeneous. This leads to application of a pooled fixed effects-type estimator for the specific parameters thus guaranteeing a convergence for the geometric means of N and T. It generates heteroskedastic cross sectional robust variance estimates using the Half Panel Jackknife estimator. This enables it to control for Nickell bias (Nickell, 1981) attributed to the pooled estimator (Dhaene and Jochamns (2015. The demeaning operation creates a regressor which cannot be independently distributed of the error term. The method has several advantages over other panel causality approaches. It is applicable in models with many cross section units, moderate time dimensions and heterogeneity of nuisance parameters. Besides its application in multivariate systems, it is able to account for both CSD and cross section heteroscedasticity. The test is also applicable in both homogeneous and heterogeneous alternatives (Xiao et al., 2023).

4.8 Definition and Measurement of Variables

Agricultural Productivity Growth (AGR_PG): This is the output net value in a sector following the summation of total outputs minus intermediate inputs. In agriculture it is therefore the net output value of agricultural production after summing up total agricultural output and subtracting agricultural intermediate inputs. It is measured as annual percentage growth in agricultural output.

Agricultural Credit (AGRCR): This refers to any of the various credit facilities used in the financing of purchases and activities in agricultural production. Availability and accessibility of agricultural credit is assumed to influence growth of productivity in agriculture. It is calculated as a ratio of total credit.

Gross Fixed Capital Formation in Agriculture (GFCFA): This is the total annual government expenditure on agriculture. It is measured as a ratio of total annual expenditure by the government. It is expected to positively influence growth in productivity.

Domestic Credit to the private sector (PVCR): These are the finances acquired by firms and individuals from financial institutions for various investments in the economy. The resources may include loans, non-equity security purchases and trade credits. It is computed as the percentage of domestic credit to GDP.

Gross Capital Formation in Agriculture (GCFA): It consists of additional capital investments by farmers in agricultural production. It is expected to positively influence growth of productivit. It is measured as the aggregate of gross additions to fixed assets, increase in inventories for stocks and net acquisition of other variables within a year.

Agricultural Labour (AGR_LABOUR): This is the number of people working in the agricultural sector per year. Labour is used for performing various activities in farm production. Farm labour is expected to positively influence productivity in the sector. It is computed as a ratio of total employment in a country.

FDI to the Agricultural sector (AGRFDI): FDI are investments made by firms or individuals from one country in another country. According to (Rutihinda, 2007), it is a means by which underdeveloped countries are integrated into global markets through increase in capital for investment. Agricultural FDI therefore provides external capital for investment in agriculture which may stimulate growth of productivity. It is expected to have a positively influence growth in productivity. It is measured as a ratio of agricultural FDI to the total FDI received in a country in a year.

Net ODA to the Agricultural Sector (AGRODA): ODA is defined as official development assistance by foreign governments aimed at promoting development and welfare in LDCs. Agricultural ODA is an important investment towards developing the sector and improving its productivity. This study will focus on ODA for the agricultural sector instead of other cash ODA allocated for general budget support. It is computed as a ratio of total ODA received in a country. It is expected to positively influence growth on agricultural productivity.

Government Effectiveness (GVEFF): This indicates the perception about quality of services offered to the public and the credibility of public policies. Percentile rank is applied as the unit for measurement in a scale of 0 to 100. The variable may have either positive or negative effects on agriculture value added.

Gross savings (GSAV): It is the part of gross disposable income which is not spent as final consumption expenditure. It therefore implies that rate of saving rises when growth of gross disposable income exceeds that of final expenditure on consumption. High savings may positively affect agricultural productivity growth due to availability of funds for investment. An assumption is made that some funds from such savings are invested in agriculture. It is measured as the GDP minus the total expenditure on consumption.

4.9 Sources of Data

Data on Agricultural Productivity Growth (Agricultural value added), Annual agricultural credit, Government expenditure on the agricultural sector, private sector domestic credit, institutional quality (government effectiveness), capital and labour will be accessed from WDI which is a publication of the World Bank. Agricultural sector FDI data will be accessed from UNCTADSTAT data set. Data on agricultural ODA will be accessed from OECD data portal.

4.10 Empirical Results and Discussion

4.10.1 Descriptive Statistics

Table 4.1: Descriptive Statistics

Variable	Mean	Std. dev	CV	Variance	Skewness	Kurtosis
AGR_PG	31.44501	8.582865	0.27294	73.66557	0.37499	2.012341
AGCR	5.897277	4.298274	0.728857	18.47516	0.505447	2.339361
GFCFA	9.221169	3.924785	0.425627	15.40394	1.813171	7.653778
PVCR	15.25143	7.836838	0.513842	61.41602	0.609850	2.822998
AGRFDI	2.035013	1.79187	0.880520	3.210799	0.813976	3.101256
GCFA	19.96463	7.744007	0.39788	59.96964	0.4443625	3.32217
AGRODA	85.69936	92.47838	1.07910	7552.25	1.984652	6.792761
GSAV	15.73773	8.264102	0.525113	68.29538	0.121438	2.260196
GOVT-EFF	29.25708	14.73304	0.503571	217.0623	0.121004	2.565108
AGR-LAB	73.66085	12.63753	0.171939	159.7072	-0.307788	2.31095

Source: Author's computation using World Bank and FAO data

In Table 4.1, the mean of agricultural productivity growth is 31.44%, an indication that growth in agricultural productivity in the EAC is still very low. Agricultural credit is just 5.895% of the total credit. Official development assistance to the agricultural sector is 85.69%, suggesting which is an indication that a large proportion of ODA is channeled to agriculture. This shows that the sector relies heavily on donor funding and external support. The coefficient of variation indicates that none of the variables has wide variations across the EAC countries. This means that the data on all variables are not significantly spread out from their means. As a result, their means may be used as the actual representation of data across EAC countries. All variables are skewed to the right. This shows that there is no variable whose data distribution has perfect symmetry.

4.10.2 Panel Unit Root Tests Results

Panel unit root test (At Levels)

Table 4.2 presents the results of panel unit root tests of the variables at levels 4.2.

Table 4.2: Panel unit root tests at levels

VARIABLE	LLC	Breitung	IPS
AGR_PG	-1.3393 (0.0902)	0.1017 (0.5405	0.0662 (0.5264)
AGCR	-0.5995 (0.2744)	-1.9307 (0.0268)	-0.0154 (0.4939)
GFCFA	-0.9837 (0.1626)	-0.4351 (0.3318)	-0.0612 (0.4756)
AGRFDI	-2.0431 (0.0205)	-3.5913 (0.0002)	-2.6948 (0.0035)
GCFA	-0.2389 (0.4056)	-0.6928 (0.2442)	-0.2554 (0.407)
AGRODA	-2.2596 (0.0119)	0.3644 (0.6422)	-4.3515 (0.0000)
GSAV	-1.4944 (0.0645)	-0.0557 (0.4778)	-2.9751 (0.0015)
GVEFF	-1.8672 (0.0309)	-1.0089 (0.1565)	-0.9808 (0.1634)
AGR_LABOUR	-1.8949 (0.2291)	4.748 (0.7489)	2.858 (0.9979)

Source: Author's computation

Table 4.2 provides panel unit root test results for Levin et al (2002) Breitung (2000) and IPS (2003). The table presents the estimated statistics and p-values (in parentheses). There is a mixed order of integration among variables. Some variables are stationary while others are not.

Panel unit root tests at first difference

Table 4.3: Panel Unit Root Tests at first differences

VARIABLE	LLC	Breitung	IPS
AGR_PG	-4.6433 (0.0000)	-4.2839 (0.0000)	-6.6856 (0.0000)
AGCR	-6.1555 (0.0000)	-4.1978 (0.0000)	-5.3395 (0.0000)
GFCFA	-5.8218 (0.0000)	-5.0772 (0.0000)	-5.2822 (0.0000)
AGRFDI	-5.0986 (0.0000)	-7.824 (0.0000)	-6.6959 (0.0000)
GCFA	-5.0888 (0.0000)	-6.0211 (0.0000)	-5.8786 (0.0000)
AGRODA	-12.0918 (0.0000)	-1.807 (0.0354)	-6.6749 (0.0000)
GSAV	-5.1759 (0.0000)	-4.5144 (0.0000)	-6.7086 (0.0000)
GVEFF	-7.5904 (0.0000)	-7.4464 (0.0000)	-6.3351 (0.0000)
AGR_LABOUR	-1.3091 (0.0053)	-2.6118 (0.0045)	-1.937 (0.0000)

Source: Author's computation

The numbers in parentheses denote p – values. Lag length selection is automatic according to Schwarz criterion. Table 4.3 indicates that the variables have a mixed order of integration. Based on these results, the ideal estimator for analyzing effects of financing on productivity growth is the Panel ARDL model.

4.10.3 Panel Cointegration Test Results

The test is applied in examining the nature of relationships between variables in the long run.

Table 4.4: Panel Cointegration test results

Kao test		
	Statistic	p-value
Modified DF t	-3.7867	0.0001
DF t	-4.3753	0.0005
ADF t	-2.5742	0.0002
Unadjusted Modified DF t	-7.1020	0.0003
Unadjusted DF t	-5.2709	0.0000
Pedroni test		
Modified PP t	2.3112	0.0104
PP t	-4.6183	0.0001
ADF t	-5.2709	0.0006
Westerlund Test		
Variance ratio	1.4864	0.0686

In Table 4.4, a majority of probabilities show that the results are significant. The null hypothesis of no cointegration is rejected. This implies a long term relationship exists between variables.

4.10.4 Slope Homogeneity Test Results

The test generates a delta test statistic using an estimator allowing for heterogeneous slopes.

Table 4.5: Slope homogeneity test results

Test	**Statistic**	**p-value**
Slope homogeneity $H_0: slope\ homogeneity$		
Delta	4.646	0.000
Delta adj.	6.117	0.000

In Table 4.5, the results are significant at 1%. We therefore reject the null hypothesis of slope homogeneity. The panel is characterized by slope heterogeneity.

4.10.6 Heteroskedasticity and Autocorrelation Test Results

A panel dataset may exhibit serial correlation. In order to test for residual autocorrelation, the test uses HAC robust standard errors in generating the estimates. The test is an extended version of Pesaran and Yamagata (20008) test by Blomquist & Westerlund (2013). Using the HAC robust estimator, transforms the slope homogeneity test into heteroskedastic robust test (Bersvendsen & Ditzen, 2021).

Table 4.6: Slope homogeneity (HAC robust) test results

Test	**Statistic**	**p-value**
Slope homogeneity $H_0: slope\ homogeneity$		
Delta	-2.520	0.012
Delta adj.	-3.317	0.001

According to Table 4.6, the results are significant at 1%. This is an indication that the panel heterogeneous. The reliability of the delta test is mainly determined by residual based assumptions, specifically if autocorrelation is present. In order to obtain optimal results, a comparison is done between standard delta test and its HAC robust equivalent in testing for autocorrelation. By comparing the standard delta test and its HAC robust equivalent, we are able to test for autocorrelation in the panel. The procedure further allows us to test for CSD if the syntax *xtcd2* is installed in Stata (Ditzen, 2018). If there is a disagreement between the two results, STATA will display a warning about the possibility of occurrence of autocorrelation. The results output will also indicate if cross sectional dependence has been detected in the base variables.

Table 4.7: Comparison of Standard Delta tests with the HAC Robust Equivalent

Test	**Statistic**	**p-value**
Slope homogeneity $H_0: slope\ homogeneity$		
Delta	4.646	0.000
Delta adj.	6.117	0.000
Delta (HAC)	-1.858	0.063
Delta adj.	-2.446	0.014

From the results in Table 4.7, there is a disagreement between the two tests. This is an indication that there is a possibility of occurrence of autocorrelation. The results further indicate that there is presence of strong CSD in the base variables. To ensure that the results of our estimation are not biased and inconsistent, we have to control for both autocorrelation and CSD in the panel.

However, before we control for both, we perform further confirmatory tests for autocorrelation and cross sectional dependence.

4.10.7 Autocorrelation Test Results

Autocorrelation exists when there is some level of correlation of same variables between successive periods. One basic OLS assumption is the independence and identical distribution of the error term. The implication is that the error term of one observation should not be influenced by the error term of another observation. Existence of autocorrelation can lead to biased and inconsistent estimates where regression estimates can falsely be reported to be correct. In this study we apply the Born and Breitung (2016) bias corrected test for autocorrelation. The test generates two bias corrected test statistics known as LM(k) and Q(p).

Table 4.8: Q test of Serial correlation results

Variable	Q(p)-stat	P-value	N	Max T	Balance
AGR-PG	55.55	0.000	5	26	balanced
AGCR	13.42	0.001	5	26	balanced
GFCFA	21.30	0.000	5	26	balanced
PVCR	34.13	0.000	5	26	balanced
AGRFDI	16.38	0.000	5	26	balanced
GCFA	6.51	0.039	5	26	balanced
AGRODA	13.84	0.001	5	26	balanced
GSAV	7.70	0.021	5	26	balanced
GVEFF	8.85	0.012	5	26	balanced
AGR_LABOUR	10.95	0.004	5	26	balanced

In Table 4.8, the null hypothesis of no serial correlation is rejected by a majority of probabilities. All the test results are significant. The results confirm the presence of autocorrelation in the panel.

Table 4.9: Lagrange Multiplier (LM) test of serial correlation results

Variable	**LM(k)-stat**	**P-value**	**N**	**Max T**	**Balance**
AGR-PG	7.34	0.000	5	26	balanced
AGCR	3.22	0.001	5	26	balanced
GFCFA	4.11	0.000	5	26	balanced
PVCR	3.84	0.000	5	26	balanced
AGRFDI	1.55	0.121	5	26	balanced
GCFA	2.56	0.011	5	26	balanced
AGRODA	2.79	0.005	5	26	balanced
GSAV	2.45	0.013	5	26	balanced
GVEFF	1.38	0.169	5	26	balanced
AGR_LABOUR	2.86	0.004	5	26	balanced

In Table 4.9, the null hypothesis of no serial correlation is rejected by a majority of probabilities. Both tests confirm that there is serial correlation in the panel. This means that we must control for serial correlation in the estimation.

4.10.8 Controlling for Heteroskedasticity and Auto correlation

Heteroskedasticity and autocorrelation makes it difficult to estimate the true standard errors. This can lead to confidence intervals that are either too wide or too narrow. In particular, they will be too narrow for out of sample predictions if the variance of the errors is increasing overtime. We therefore apply the FGLS test and the PCSE tests to control for heteroscedasticity and autocorrelation in the panel.

Table 4.10: GLS and PCSE Estimation Results

Variable	Generalized Least Squares Estimation			Panel Corrected Standard Error Estimation		
AGR_PG	Coefficients	Std. error	p-values	Coefficient	Std. Error	p-values
AGCR	0.1241076	0.1701293	0.466	0.1241076	0.1835889	0.499
GFCFA	0.9427974	0.1820192	0.000	0.9427974	0.1937387	0.000
PVCR	-0.7459196	0.1020338	0.000	-0.7459196	0.0984781	0.000
AGRFDI	-0.4902211	0.356919	0.170	-0.4902211	0.3629423	0.177
GCFA	0.2057876	0.1091346	0.059	0.2057876	0.1128869	0.068
AGRODA	0.007646	0.0083073	0.358	0.007646	0.0077753	0.326
GSAV	-0.1983819	0.0950531	0.037	-0.1983819	0.0854723	0.020
GVEFF	-0.0649543	0.0460577	0.158	-0.0649543	0.439133	0.139
AGR_L	0.0327053	0.0603328	0.588	0.0327053	0.0590399	0.580
_Cons	32.24396	6.258602	0.000	32.24396	6.090913	0.000
	Estimated Covariances 15			1		
	Estimated autocorrelation 0			0		
	Estimated Coefficients 10			10		
	Prob > Chi2 0.0000			0.000		

Table 4.10 provides evidence that there is no autocorrelation in the dataset. By a majority of probabilities, the test results are significant at 1%, 5% and 10%. This is achieved after application of PCSE and FGLS estimation techniques to control for autocorrelation. The test results further confirm that the panels are correctly balanced.

4.10.9 Cross Sectional Dependence Test Results

Table 4.11: Cross Sectional Dependence Test Results

Variable	CD	CDw	CDw+	CD*
AGR_PG	10.80 (0.000)	3.55 (0.000)	37.71 (0.000)	0.40 (0.691)
AGCR	-1.80 (0.071)	-2.84 (0.005)	16.22 (0.000)	3.34 (0.001)
GFCFA	0.65 (0.513)	2.74 (0.006)	21.26 (0.000)	5.23 (0.000)
PVCR	10.39 (0.000)	-0.98 (0.328)	31.88 (0.000)	0.24 (0.807)
AGRFDI	2.56 (0.011)	-0.72 (0.474)	8.09 (0.000)	0.53 (0.598)
GCFA	10.96 (0.000)	-2.38 (0.017)	32.29 (0.000)	1.12 (0.261)
GSAV	0.28 (0.779)	1.42 (0.155)	9.33 (0.000)	2.62 (0.009)
GVEFF	1.68 (0.092)	1.05 (0.293)	22.61 (0.000)	3.83 (0.000)
AGR_LABOUR	-2.21 (0.027)	1.37 (0.169)	22.33 (0.000)	1.93 (0.054)

In Table 4.11, by a majority of probabilities, we therefore reject the null hypothesis of weak CSD. The results are significant at 1%, 5% and 10%. The panel is characterized by strong CSD. The estimation method must account for the strong CSD.

4.10.10 Accounting for Cross Sectional Dependence

If strong CSD is not controlled, it may lead to bias and inconsistency in the estimates. This is because the unobserved dependence makes the error term to be auto-correlated and thus leads to a bias (omitted variable bias). CD can be accounted for by using principal components model (Bai, 2009) or CSA method (Pesaran, 2006). The method by Pesaran (2006) does not require the identification of common factors prior to performing the estimation unlike the principal components model. It is called the common correlated effects (CCE) estimator. Addition of CSA as further covariates, approximates the strong CSD in order to account/control for its effect.

Table 4.12: Comparison of Mean Group Estimator and Common Correlated Effects (CCE) Pooled Estimation

$H_0: slope\ coefficients\ are\ homogeneous$	
Delta	p-value
-7461.718	0.000
Adj. -5814.124	0.000

In Table 4.12 the results are significant at 1% level. After estimation using CSA as covariates, strong CSD is eliminated from the panel.

4.10.11 Multicollinearity Test Results

The correlation between explanatory variables in a model may lead to multicollinearity. This can result to skewed and misleading results. The probabilities used in the analysis between the dependent variables and independent may also become unreliable. Presence of multicollinearity complicates the process of determining the effect of explanatory variables on dependent variables.

Table 4.13: Multicollinearity test results

Variable	VIF	1/VIF
GCFA	3.73	0.268396
PVCR	3.34	0.299822
GSAV	3.22	0.310677
AGRODA	3.08	0.324814
AGR_LABOUR	3.03	0.329762
AGCR	2.79	0.358497
GFCFA	2.66	0.375635
GVEFF	2.40	0.416336
AGRFDI	2.13	0.468684
Mean VIF	2.93	0.350291

We use the Variance Inflation Factor (VIF) in testing for multicollinearity. If the VIF value is less than 5, then there is no major problem with multicollinearity. If the range is between 5 and 10, there is moderate effect of multicollinearity. However, VIF values greater than 10 is enough evidence that multicollinearity is a major problem that needs to be controlled. In Table 4.13, our VIF values are all less than 5. This confirms that multicollinearity poses no problem to the model.

4.10.12 Panel CS-ARDL Estimation Results

The panel unit root tests indicated that the variables had a mixed order of integration. This provides justification for the use of panel ARDL model. Our estimation results provided evidence of strong CSD Due to the presence of strong cross CSD, we apply the cross sectional augmented ARDL (CS-ARDL) technique in estimating the relationship between variables (Chudik et al., 2016 and Ditzen, 2021).

Table 4.14: Panel CS-ARDL estimation results

Common Correlated Effects Estimator – (CS-ARDL Panel)			
Variables	**Coefficients**	**Std. Error**	**p-value**
	Short run estimation		
L.AGR_PG	0.0715998	0.1292674	0.000
AGCR	0.016703	0.1978455	0.013
GFCFA	0.6929826	0.2214778	0.000
PVCR	0.024747	0.1189037	0.316
AGRFDI	0.128363	0.4685383	0.423
GCFA	0.0220226	0.141206	0.002
AGRODA	0.0197103	0.011116	0.529
GSAV	0.1740522	0.120369	0.217
GVEFF	0.0552307	0.0584916	0.016
AGR_LABOUR	0.0734538	0.1779343	0.023
	Long run estimation		
AGCR	0.6421027	0.0653931	0.000
GFCFA	1.2290283	0.0786967	0.000
PVCR	-1.188989	0.0366041	0.197
AGRFDI	0.1420523	0.1888837	0.452
GCFA	0.5203269	0.0432512	0.000
AGRODA	0.0004487	0.0048072	0.351
GSAV	-0.152658	0.0392415	0.213
GVEFF	0.1084407	0.0193461	0.000
AGR_LABOUR	0.5278134	0.0813147	0.012

According to the results in Table 4.14, agricultural credit, government agricultural sector expenditure, capital formation in agriculture, government efficiency and labour have a positive influence on growth of productivity in agriculture. These variables drive productivity growth in the short run. A 1% increase in agricultural credit, government agricultural sector expenditure, gross capital formation in agriculture, government efficiency and agricultural labour increases agricultural productivity by 0.07, 0.01, 0.69, 0.05 and 0.07 units respectively. The variables are also significant determinants of growth in the long run. If agricultural credit, government agricultural sector expenditure, gross capital formation in agriculture, government efficiency and agricultural labour are increased by 1%, then productivity growth in agriculture increased by 0.64, 1.22, 0.52, 0.10 and 0.52 units respectively.

4.10.13 Panel Granger Causality Test Results

We apply the new method for testing causality proposed by Xiao et al. (2023). The method is compatible with models characterized by both homogeneous and heterogeneous coefficients. One main feature of this test is that Granger-causality parameters are homogeneous and thus equal to zero under the null hypothesis. This enhances the implementation of pooled fixed effects type estimator for the parameters. Using a BIC criterion, it allows for manual as well as automatic lag selection. It also generates regression results according to Half-Panel Jackknife (HPJ) bias corrected pooled estimator (Xiao et al., 2023). The test allows for CSD and cross sectional heteroscedasticity in the errors and the panel must be balanced.

Table 4.15: Panel Causality results

Null hypothesis	**Wald Statistic**	**P-value**	**Decision**	**Causality inference**
AGCR does not cause AGR_PG AGR_PG does not cause AGCR	2.6643 2.0660	0.0280 0.0585	Reject Reject	Bidirectional causality
GFCFA does not cause AGR_PG AGR_PG does not cause GFCFA	0.1623 6.0765	0.8810 0.0075	D.N.R Reject	Unidirectional causality
AGRFDI does not cause AGR_PG AGR_PG does not cause AGRFDI	1.2328 0.5208	0.0535 0.5180	Reject D.N.R	Unidirectional causality
GCFA does not cause AGR_PG AGR_PG does not cause GCFA	-0.1938 5.8631	0.0040 0.8890	Reject D.N.R	Unidirectional causality
AGRODA does not cause AGR_PG AGR_PG does not cause AGRODA	0.0143 6.1114	0.0020 0.9845	Reject D.N.R	Unidirectional causality
GSAV does not cause AGR_PG AGR_PG does not cause GSAV	0.9279 -0.5727	0.3830 0.5955	D.N.R D.N.R	No causality
PVCR does not cause AGR_PG AGR_PG does not cause PVCR	2.5132 5.4457	0.3450 0.1385	D.N.R D.N.R	No causality
GVEFF does not cause AGR_PG AGR_PG does not cause GVEFF	1.7614 2.1385	0.1435 0.1925	D.N.R D.N.R	No causality
AGR_PG does not cause AGR_L AGR_L does not cause AGR_PG	-0.4904 4.3124	0.0000 0.0760	Reject Reject	Bidirectional causality

According to Table 4.15, a bidirectional causal flow exists between growth in agricultural productivity and agricultural credit. This is an indication that the variables enjoy a feedback relationship. The causality runs from agricultural credit to agricultural productivity growth and vice versa. This justifies the need to have a sustainable, stable and well-functioning agricultural credit system. Agricultural production is vulnerable to various risks and uncertainties which are part of the production process. Accessibility of credit is important in mitigation of such risks to ensure sustainability of growth in agricultural productivity in addition to efficient production decisions. The presence of a well-developed system of agricultural finance therefore influences aggregate growth in productivity. These findings agree with those of Seven and Tumen (2020), Ali et al., (2014) and Fowowe (2020).

A unidirectional causal flow exists between government expenditure on agriculture and productivity growth. The causality runs from productivity growth to government expenditure. This is an indication that growth in agricultural productivity induces changes in government agricultural sector expenditure. This is an indication that Wagner's Theory (Wagner, 1876) applies in the relationship between government agricultural sector expenditure and agricultural productivity in the EAC. This result does not agree with that of Ngobeni and Muchopa (2022) who argued that government expenditure has no effect on agricultural productivity. However, the finding that productivity growth in agriculture causes adjustments in government agricultural sector expenditure equally applies to the findings of Megobowon et al. (2019) and Ayoub & Mivumbi (2019). The findings underscore the critical role played by government financing on on growth of productivity in an environment characterized by impacts of climate change and enhanced commercialization of agricultural production. No causal flow runs from government expenditure on agriculture to agricultural productivity growth. Therefore, we do not reject (D.N.R) the null hypothesis of granger non causality.

There is unidirectional causality between FDI to agriculture and growth in agricultural productivity. The causality runs from FDI to agricultural productivity growth. FDI can contribute to enhanced productivity and innovation through activities of foreign firms (direct impact) and through the channel of technology and knowledge spillovers. This is as a result of market interactions with domestic firms (indirect impact) because foreign firms tend to be larger and more input sensitive. They also have easier access to foreign markets in comparison to domestic firms. Due to their superior mechanic prevalence, they can increase the average labour productivity and performance of exports. FDI is critical in the inflow of latest scientific research and modern farming technologies. These will lead to enhanced growth in productivity. The findings agree with those of Don and Newlth (2015) and Edeh and Eze (2020).

Capital formation in agriculture and agricultural productivity growth enjoy a unidirectional causal relationship. The causality runs from agricultural capital to agricultural productivity. Growth of capital (capital deepening) enhances labour productivity. Access to credit enhances the productive capacity of farmers which leads to growth in productivity. The accumulation of capital goods leads to production of more goods which can boost income of the population and stimulate demand. A rise in investment contributes to growth of aggregate demand and increases the productive capacity. This result is in agreement with that of Morgues et al. (2012) who provided evidence that agricultural investment enhances growth of productivity in the sector. However, according to Eke and Effiong (2016), capital formation in agriculture does not significantly affect productivity growth in agriculture.

There is a unidirectional causality between ODA to the agriculture and productivity growth. The causality runs from agricultural ODA to agricultural productivity. Due to domestic resource constraints, most of the developing countries are highly reliant on foreign assistance in order to support sustainable development programmes in agriculture. Due to the significant role of agriculture in employment creation and GDP growth, EAC has been a regular recipient of ODA. This result agrees with Ssozi et al. (2019) and Barakat and Alsamara (2019). Both studies agree that SSA agriculture has been receiving substantial amount of foreign aid from OECD and other international institutions. The influence of foreign aid to agriculture in Asian countries has played a crucial role in Asia's Green Revolution and the impact on the reduction of poverty and economic transformation has been evident. Therefore, for ODA to achieve its full potential, it requires the support of quality institutions.

The bi-directional causality between agricultural productivity growth and agricultural labour shows that labour significantly influences productivity growth agriculture. Likewise, growth of agricultural productivity stimulates the demand for additional labour to work in the farms. Agriculture in the EAC is a labour intensive exercise and needs regular supply of labour because the bulk of production is done by small scale farmers. Labour productivity is mainly driven by capital investment, technological progress and human capital development. High quality of labour affects the productivity, profitability and long term sustainability of all agricultural commodities.
Table 4.15 also reports that gross domestic savings, private sector credit and government efficiency do not enjoy any causal relationships with agricultural productivity growth. Evidence of no causal flow between domestic savings, private sector credit and productivity growth may be attributed to the channels through domestic savings are transmitted into the agricultural value chain. Financial resources in form of savings are utilized in agriculture through purchase of farm inputs, payment of labour services, agricultural processing and marketing. This is supported by evidence of causality between agricultural productivity growth and gross capital formation in the sector as well

as labour. Absence of causality between agricultural productivity growth and government efficiency may be due to how the policy environment and framework affects the sector. The financial sector in affected by several policies. Key among them include fiscal and monetary policies. There are also various specific policies for the agricultural sector. These policies influence the macroeconomic environment and have a direct effect on the agricultural sector. The policy environment may either promote and limit the amount of finances flowing into the agriculture. According to Ssozi et al., (2019), the flow of ODA is mainly determined by the quality of institutions. Therefore, the role of government efficiency on productivity growth may be through its effects on various agricultural financing channels.

4.10.14: Half-Panel Jackknife Estimation Results

The causality test results provide evidence of the nature and direction of causality. For robustness of the results and to account for Nickell bias of the pooled estimator, the test generates regression results according to the Half Panel Jackknife bias-corrected pooled estimator. The results are also known as cross-sectional heteroskedasticity robust variance estimation results.

Table 4.16: Half-Panel Jackknife Estimation Results

Variable	Coefficient	Std. Error	p-value
Agricultural Productivity Growth ; Agricultural credit	0.1859062	0.098723	0.060
Agricultural Credit ; Agricultural Productivity Growth	-0.0745124	0.05137	0.147
Agricultural Productivity Growth; Government Agricultural Expenditure	0.233644	0.0694159	0.001
Government Agricultural Expenditure; Agricultural Productivity Growth	-0.0490645	0.1062339	0.644
Agricultural Productivity Growth; Private Sector credit	0.1519062	0.14548	0.296
Private Sector Credit; Agricultural Productivity Growth	0.1317248	0.068367	0.054
Agricultural Productivity Growth; Agricultural FDI	0.950194	0.144213	0.000
Agricultural FDI; Agricultural Productivity Growth	0.092511	0.032256	0.004
Agricultural Productivity Growth; Gross Capital Formation in Agriculture	0.2711066	0.346768	0.000
Gross Capital Formation in Agriculture; Agricultural Productivity Growth	0.0696658	0.0273057	0.011
Agricultural Productivity Growth; Agricultural ODA	0.0245224	0.0032362	0.000
Agricultural ODA; Agricultural Productivity Growth	3.0505518	1.428458	0.303
Agricultural Productivity Growth; Gross Savings	0.1287568	0.0621421	0.039
Gross Savings; Agricultural Productivity Growth	-0.2763308	0.0627094	0.142
Agricultural Productivity Growth; Government Efficiency	-0.000314	0.023562	0.894
Government Efficiency; Agricultural Productivity Growth	0.1115668	0.302373	0.712
Agricultural Productivity Growth; Agricultural Labour	1.464476	0.0516592	0.000
Agricultural Labour; Agricultural Productivity Growth	0.4224153	0.0719809	0.000

Table 4.16 provides evidence that agricultural credit significantly influences agricultural productivity growth. A 1% increase in agricultural credit increases agricultural productivity growth by 0.1859 units. Government agricultural sector expenditure has a significant positive effect on agricultural productivity growth. A 1% change in government expenditure on the

agricultural sector increases agricultural productivity by 0.2336 units. Agricultural productivity growth has positive effect on private sector credit. A 1% increase in agricultural productivity increases private sector credit by 0.1317 units. This is an indication that part of private sector credit is invested in agriculture. FDI to the agriculture influences productivity in agriculture. A 1% increase in agricultural FDI increases agricultural productivity by 0.9501 units. Agricultural productivity positively influences agricultural FDI. Changes in agricultural productivity influences growth of agricultural FDI. A 1% increase in agricultural productivity increases agricultural FDI by 0.0925 units.

Gross capital formation in agriculture has a significant positive effect on agricultural productivity. A 1% increase in capital formation increases growth of productivity in agriculture by 0.2711 units. Changes in agricultural productivity have a positive effect on gross capital formation in agriculture. A 1% change in agricultural productivity increases capital investment in agriculture by 0.0696 units. Official Development Assistance to agriculture boosts its productivity. A 1% increase in ODA increases agricultural productivity by 0.0245 units. Gross savings has a significantly influences growth of productivity. A 1% increase in gross savings increases agricultural productivity by 0.1287 units. Agricultural labour enhances growth of productivity in agriculture. When agricultural labour is increased by 1%, agricultural productivity improves by 1.4644 units. Agricultural productivity growth is a significant positive determinant of agricultural labour. Changes in agricultural productivity positively influence changes in agricultural labour. A 1% increase in agricultural productivity growth increases agricultural labour by 0.4224 units. This is an indication as productivity levels increase in agriculture, there is demand for more labour to work in the farms.

4.11 Summary and Conclusions

The study was conducted to evaluate the effect and causal flow between agricultural productivity growth and agricultural financing. Panel unit root tests indicated that the variables had a mixed order of integration. The cointegration results showed that the variables had a long term relationship. Test for slope homogeneity was done using Pesaran & Yamagata (2008) test which confirmed the presence of cross sectional heterogeneity in the panels. A comparison of the results of the standard delta test and its HAC robust equivalent, revealed the possibility of occurrence of autocorrelation and presence of strong CSD. The results were confirmed through Born and Breitung (2016) bias corrected test for autocorrelation. To control for autocorrelation, we applied both iterated generalized least squares and panel corrected standard error approaches in the estimation. The strong CSD was accounted by estimating the common correlated effects with the cross sectional averages as proposed by Pesaran (2006). Analysis of the short run and long run relationship between variables was done using CS-ARDL Model. Agricultural credit, government agricultural sector expenditure, capital formation in agriculture, government efficiency and labour significantly influenced agricultural productivity growth.

The nature and direction of causality was evaluated using panel granger causality. This was because of strong CSD in the panel. Granger causality results indicated that agricultural credit and agricultural labour had bidirectional causal relationships with agricultural productivity growth. However, government agricultural sector expenditure, ODA to the agricultural sector, agricultural FDI and gross capital formation in agriculture had a unidirectional causal relationship with agricultural productivity growth. According to these results, government agricultural spending, capital investment in agriculture and foreign direct investment and official development assistance to agriculture positively affected agricultural productivity growth. The results also indicate that both agricultural credit and labour exert significant influence on productivity growth in agriculture. Agricultural productivity growth also influences changes in agricultural credit and agricultural labour.

4.12 Policy Implications

The study has confirmed that agricultural credit and government expenditure on agriculture are important determinants of agricultural productivity growth. EAC governments should implement policies which will promote accessibility and affordability of credit by farmers in order to enhance productivity growth. Governments should review their budget policies and allocate additional funds to the agricultural sector. This policy implication is in agreement with Maputo (2003) and Malabo (2014) declarations that recommended that 10% government budgets should be allocated to agriculture in order to boost its productivity. Due to the effects of climate change, reliance on rain fed agriculture is becoming a challenge to farmers. There is need to invest in irrigation to boost agricultural productivity growth. This requires allocation of adequate financial resources to the sector.

Governments should improve the quality of their institutions by developing sound policies aimed promoting agricultural growth and development to enable them attract ODA and FDI to the sector. Farm inputs should be made affordable to farmers in order to reduce the cost of production. Agricultural extension and training should be intensified to build the capacity of farmers and agricultural labour.

4.13 Limitations of the study

Institutionalized agricultural credit is mainly accessible to large scale and commercial farmers. The informal financial sector is a major source of funding for small scale farmers. However, lack of data on informal agricultural credit across the EAC made it impossible to include the variable in the study. The study only focused on five EAC members because the period of membership for other countries (Southern Sudan and DRC Congo) could not fit into the scope of the study. The methodology applied in causality analysis did not generate individual country causality results.

4.14 Areas for Further Research

The study focused on the role of agricultural financing on agricultural productivity growth. However further studies can be done focusing on how agricultural financing affects either crop or livestock productivity. Studies could also assess the contribution of financing on productivity of specific crops such as coffee, tea, maize and sugar or livestock production like dairy farming, poultry keeping among others. Financial markets are normally affected by various shocks that may interfere with their operational efficiency. Future studies could introduce structural breaks to account for shocks which affect agricultural productivity growth. The study could also be replicated in other RTAs in SSA and comparisons done with the outcome of this study.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

5.1 Introduction

This chapter concludes the thesis by providing summary and conclusions, main findings, policy implications, limitations of the study, contribution to knowledge and proposes areas for further research.

5.2 Summary and Conclusions

The thesis analyzed the trends and determinants of agricultural productivity in the EAC. Malmquist Productivity Index was estimated using DEA. The index was decomposed into its components; total factor productivity change, efficiency change and technical change. The results indicated that productivity grew by 0.5% while technical change increased by 0.9%. This is an indication that growth in productivity was determined by technical change. Efficiency change was negative, an indication that the EAC countries were drifting away from the efficient frontier. When the efficiency change is decomposed into its components, it revealed negative growth in both pure technical efficiency and scale efficiency. The negative growth in scale efficiency indicated that the agricultural sector in the EAC was not operating at its optimal capacity. The negative growth in pure technical efficiency was due to skill and managerial inefficiencies in agricultural production. The low growth in productivity was therefore attributed to negative growth of efficiency, managerial inefficiencies and failure to operate at optimal capacity. It was also discovered that, during the period all the DMUs were operating at a decreasing returns to scale.

By comparing the productivity index between Pre_EAC and Post_EAC periods, it was confirmed that only TFP and technical change registered positive improvements. All the other Malmquist productivity index components registered negative growth. It also showed that four out of five EAC countries achieved a positive growth in agricultural productivity. However, the growth rate was less than one percent. There was a positive growth in technical change among all countries. This implied that the countries had embraced technology adoption and innovation in agricultural production. In the second estimation, the study analyzed productivity determinants. In this analysis, the efficiency scores generated in stage 1 (DEA estimation) were regressed against productivity determinants using Tobit regression. Due to limitations of the Tobit regression, truncated regression and simarwilson two stage bootstrap regressions were also used to assess the reliability of the results. The tests confirmed that government efficiency and corruption control significantly influenced productivity.

The study also analyzed the effect of agricultural trade openness on agricultural productivity. All variables were cointegrated and integrated of order one. There was cross sectional heterogeneity and strong cross sectional dependence in the panel. The strong CSD was accounted for by approximation using CSAs as further covariates in the estimation. The effects of agricultural trade openness on agricultural productivity was estimated using panel cointegration regression techniques (FMOLS, DOLS and CCR). The regression results showed that agricultural trade openness, government regulatory quality and agricultural labour had significant positive effects on agricultural productivity. Pairwise panel granger causality tests revealed unidirectional causal relationships between agricultural productivity and trade openness. There was no causality between agricultural productivity and government regulatory quality. This could be interpreted to mean that regulatory quality affected productivity indirectly through other variables. The results of this estimation provided evidence that openness had a positive influence on agricultural productivity.

The study further examined the role of agricultural financing on agricultural productivity growth. The variables had a mixed order of integration. The variables were also cointegrated. Slope homogeneity tests revealed that the panel was characterized by cross sectional heterogeneity. The comparison between standard delta test results and its heteroscedastic and autocorrelation robust equivalent indicated the possibility of autocorrelation in the panel. The test also detected strong CSD in the base variables. Given that the time series dimension of the data set is longer than the cross sectional dimension, panel iterated generalized least squares was applied in controlling for autocorrelation. However, for robustness of the results panel corrected standard errors was also applied in the estimation. The model was estimated using cross sectional averages as further covariates to control for strong CSD. Due to mixed order of integration in the variables, Panel CS-ARDL was deemed suitable for estimating the effect of financing on agricultural productivity growth. Agricultural credit, government expenditure on agriculture, capital formation in agriculture and government efficiency had significant positive effects on the growth of agricultural productivity. Gross savings had a negative effect on agricultural productivity. Pairwise panel granger causality tests showed that both agricultural credit and agricultural labour enjoyed a bidirectional causality with agricultural productivity growth. There was unidirectional causality between agricultural productivity and agricultural gross capital formation, government expenditure and official direct assistance to agriculture. Changes in agricultural productivity growth influenced changes in government agricultural sector expenditure, agricultural gross capital formation and official direct assistance to agriculture. Changes in agricultural credit and agricultural labour influenced changes in agricultural productivity growth and vice versa.

Based on the outcomes of this study we draw three main conclusions. First, agricultural productivity in the EAC is mainly determined by technical change. Therefore, EAC countries should embrace technology adoption and innovation to enhance agricultural productivity. Secondly, agricultural trade has a positive influence on agricultural productivity. These findings therefore call for enhanced role of agricultural trade promotion though RTAs. This should be supported by building the capacity agricultural value chain institutions. Thirdly, the study provides evidence that agricultural financing promotes growth of productivity in agriculture. Agricultural credit, government agricultural sector expenditure and government efficiency contribute to growth of productivity. This is further confirmation that like trade, agricultural finance should be complemented by strong institutions.

5.3 Policy Implications

This thesis has confirmed that lagging productivity in the EAC agricultural sector is attributed to negative growth in efficiency change, managerial inefficiencies and scale inefficiencies. Trade openness, institutional quality and agricultural financing are significant determinants of agricultural productivity and its growth. Agricultural training institutions should be expanded and strengthened to enable farmers acquire modern skills in agricultural production. Agricultural research and development strategies should be enhanced to produce high yielding crop varieties and livestock varieties. The research and development policies should generate new and innovative technologies that can enhance the resilience of agriculture to the adverse effects of shocks and climate change. Policy makers should ensure that there is constant availability of affordable agricultural inputs.

Due to the significant contribution of openness in promoting agricultural productivity, the governments of the EAC countries should promote trade and investment policies which are aligned with the regional strategy. Existing trade barriers should be removed to improve the efficiency and effectiveness of regional trade. EAC countries should pursue policies aimed at expanding the regional market by devising strategies to attract more members. Government policies play an important role in providing an enabling environment that may promote growth in productivity and enhance the competitiveness of agricultural products. This is achieved through appropriate investments in transport infrastructure, education and research and development. Trade distorting policies that restrict trade or unnecessarily increase trade costs should be reviewed to promote the efficiency of open trade.

The study has revealed that agricultural credit and government expenditure significantly influence productivity growth in agriculture. EAC governments should pursue policies that promote accessibility of affordable credit in order to boost productivity growth in agriculture. Development of agricultural farm infrastructure, markets and provision of agricultural extension services should be promoted. Governments should develop sound policies aimed promoting agricultural growth and development to enable them attract official development assistance to the sector. Finally, in line with the Maputo (2003) and Malabo (2014) declarations, EAC governments should allocate more funds from their annual budgets to agriculture. The financial allocations to agriculture sector by the EAC countries should march the sector's contribution to economic growth.

5.4 Contribution of the Study to Knowledge

The thesis makes a significant contribution to literature on agricultural productivity. While existing studies analyzed productivity trends of specific crops in various countries, this study focuses on the productivity trends of the whole agricultural sector. Previous studies mainly focused on crop production while leaving out the livestock sub sector. The sub sector has grown and it is major contributor to agricultural production. Many studies on productivity have deployed the two stage DEA analysis in which efficiency scores generated through DEA are regressed against productivity determinants using Tobit regression. The thesis extends this discussion by using truncated regression and simarwilson bootstrap analysis.

The study provides evidence that agricultural trade openness improves productivity. The effect of RTAs on agricultural productivity varies across countries due to heterogeneity. We also document that regulatory quality promotes agricultural productivity. The study indicates that agricultural financing influences growth of productivity in agriculture. We provide evidence that agricultural credit, government agricultural sector expenditure and government effectiveness (institutional quality) promote productivity growth. To account for differences across countries in our analysis, our slope homogeneity tests confirmed the presence of heterogeneity which was factored in the analysis. We further provide evidence that there is cross sectional dependence between EAC countries. Therefore, a shock emanating from one EAC country can be easily transmitted to others.

5.5 Limitations of the Study

The thesis focused on the EAC. However, only five out of seven members could be included in the analysis. Agricultural research and extension is a major determinant of agricultural productivity. However, there was no reliable data on the variable making it impossible to include it in the study. Due to challenges occasioned by climate change, over reliance on rain fed agriculture is posing a serious threat to agricultural production. Agricultural production using irrigation is one of the strategies that needs to be embraced to improve productivity. Complete data on agricultural land under irrigation was not available. Small scale farmers mainly seek financing from the informal financial sector. However, lack of data on informal finance across the EAC made it impossible to include the variable in our analysis.

5.6 Areas for Further Research

Further research in this topic can be extended to other aspects like agricultural processing and value addition by examining their contribution to agricultural productivity. This study focused on the EAC even though SSA has several RTAs. Comparative research across regions may be worth conducting to assess if the findings of this study applies to other regions. The reasons for the continued operation of the agricultural sector under decreasing returns to scale should be examined. Agricultural production in the region is operating below its optimal capacity, a matter that needs further investigation in order to recommend interventions to address scale inefficiency. The effects of openness on productivity of specific crops and livestock output requires further analysis. Membership to more than one RTA may influence how openness affects agricultural productivity. This may require further investigation and analysis. Further studies may analyze the effects of agricultural financing on productivity of specific crops and livestock varieties. Studies may assess the contribution of financing on maize farming, sugar production, tea farming, poultry farming and dairy farming among others. The nexus between agricultural productivity and climate change is a potential subject for further research. Variables in the economic system are affected by various shocks. Testing and estimation of structural breaks as well as their effects on agricultural productivity may also be topics for further analysis.

REFERENCES

Abubakar, A., & Gani, I. (2013). Impact of Banking Sector Development on Economic Growth: Another Look at the Evidence from Nigeria. *Journal of Social Sciences, 2* (14), 47-57.

Aboushady, N., Zaki, C., & Roy, D. (2022). *The Three Great Stimulants: An Analysis of Cocoa, Coffee and Tea Value Chains in Africa. "In the African Agricultural Trade Monitor 2022,* *edited by A. Bouet, P-S Odjo, and C. Zaki, 88-138.* Kigali, Rwanda: Akademiya 2063; Washington, DC: IFPRI: International Food Policy Research Institute.

ADB. (2016). *Feed Africa: Strategy for Agricultural Transformation in Africa, 2016 - 2025.* Abidjan: African Development Bank.

ADB (2000). *African Development Report 2000. Review of Economic Development in Africa.* African Development Bank Group.

ADB (2001). *African Development Report 2001: A Summary.* Abidjan, Cote d'Ivoire: African Development Bank.

ADB (2010). *African Development Report 2010: A Summary.* Abidjan, Cote d'Ivoire: African Development Bank.

Adegun, A. (2013). *The Economic Commission for Africa and Africa's Economic Integration. A Historical Analysis.* Lagos, Nigeria: Unpublished PhD Seminal Paper Presented at the Department of History and Strategic Studies, University of Lagos.

Adelman, I. (2001). Fallacies in development theory and their implications for policy. *The future in perspective* , pp. 103-135.

Adeola, O., & Evans, O. The impact of microfinance on financial inclusion in Nigeria. . *The Journal of Developing Areas, 51* (10), 193-206.

Afangideh, U. (2009). Financial Investment and Agricultural Development in Nigeria: Historical simulation Approach. *Journal of Economic and Monetary Integration, 9*, 74-97.

Afonso, O. (2001). The Impact of International Trade on Economic Growth. *FEP Working Papers, No. 106* .

Agbada, A. (2015). Agricultural Financing and Optimizing Output for Sustainable Economic Development in Nigeria. *Journal of Emerging Trends in Economics and Management Sciences (JETEMS), 6* (5), 359-366.

Ahmad, N. (2011). Impact of Institutional Credit on Agricultural Output: A Case study of Pakistan. *Theoretical and Applied Economics, 10* (563), 99-120.

Ajayi, M., Nageri, K., & Akolo, C. (2017). Impact of Agricultural Financing Policy and Deposit Money Bank Loans on Agricultural Sector Productivity in Nigeria. *Amity Journal of Agribusiness, 2* (1), 1-11.

Akpaeti, A. (2015). Impact of Financial Sector Reforms on Agricultural Growth in Nigeria: A Vector Autoregressive (VAR) Approach. *American Journal of Experimental Agriculture, 7* (10), 17-35.

Aldieri, L., Brahmi, M., Chen, X., & Vinci, C. (2021). Knowledge spillovers and technical efficiency for cleaner production: an economic analysis from agriculture innovation. *J. Clean. Prod.,* 320, 128830. doi:doi:10.1016/j,jclepro.2021.128830.

Ali, S. (2020). Exchange Rate Effects on Agricultural Exports. Transaction - Level Evidence from Pakistan. *American Journal of Agricultural Economics, 7*(31), 1020-1044. doi:https://doi.org/10.1002/ajae.12077.

Ali, D., Deininger, K., & Duponchel, M. (2014). Credit Constraints and Agriculture Productivity. Evidence from Rural Rwanda. *Journal of Development Studies*, 649-665.

Alene, A. (2010). Productivity Growth and the Effects of Research and Development in Agriculture. *Journal of Agricultural Economics, 41* (3-4), 223-238.

Ameziane, K., & Benyacoub, B. (2022). Exchange rate volatility on economic growth under different exchange rate regimes. New evidence from emerging countries using panel CS-ARDL model. *Journal of Risk and Financial Management*, 1-20. Retrieved from https://doi.org/10.3390/jrfm15110499.

Anaman, K. (2004). Anaman, K.A. (2004) Determinants of Economic Growth in Brunei Darussalam 15, . https://doi.org/10.1016/j.asieco.2004.05.019. *Journal of Asian Economics, 15* (4), 777-796.

Andersen, L., & Babula, R. (2008). The Link between Openness and Long run economic growth. Journal of International Commerce and Economics. United States International Trade Commission. *Journal of International Commerce and Economics* .

Anowor, O., Ukweni, N., & Ikeme, M. (2013). The Impact of Trade Liberalization on Nigeria Agricultural Sector. *Journal of Economics and Sustainable Development, 4* (8), 14-23.

Ansari, F., Baharudin, N., Jusoh, N., Mohamed, Z., Shamsudin, N., & Jusof, K. (2011). A Vector Error Correction Model (VECM) Approach in explaining the relationship between interest rate and inflation towards exchange rate volatility in Malaysia. *Journal of Applied Economics, 12* (3), 49-56.

Aworawo, D. (2006). Integration, Globalization and Africa's Devellopment. The experiences of Nigeria and Botswana. *Nigerian Journal of Policy and Development*, 23-52.

Ayyagari, M., Asli, D., & Vojislav, M. (2006). How Important Are Financing Constraints? The role of Finance in the Business Environment. *The World Bank Economic Review, 22* (3), 1-60.

Ayoe, H. (2007). Second Stage DEA. Comparison of approaches for modelling the DEA score. *European Journal of Operation Research*(181(2007)), 425-435.

Ayoub, Z., & Mivumbi, M. (2019). The impact of public expenditure on the agricultural sector productivity in China. *American Journal of Humanities and Social Sciences Research, 3*(9), 173-180.

AU. (2003). Declarations, Assembly of the African Union. *Second Ordinary Session, July 10 - 12, 2003.* Maputo, Mozambique: African Union Secretariat.

AU - NEPAD. (2003). Comprehensive Africa Agriculture Development Programme (CAADP). *AU - NEPAD CONFERENCE.* Midrand, South Africa: African Union - New Partnership for African Development.

Ayyagari, M., Demirguc-Kunt, A., & Maksimovic, V. (2008). Formal vs Informal Finance: Evidence from China. *Policy Research Working Paper Series* .

Badunenko, O., & Tauchmann, H. (2018). Simar and Wilson two-stage efficiency analysis for stata. *FAU Discussion Papers in Economics*(No. 08/2018), pp. 1-37.

Bahegot, W. (1873). *A Description of the Money Market, Lombard Street, Homewood, Il.,* . Richard D. Irwin.

Bai, J. (2009). Panel Data Models with Interactive Fixed Effects. *Econometrica, 77*(4), 1229-1279.

Balan, F. (2015). The Nexus between Political Instability, Defence Spending and Economic Growth in the Middle East Countries: A Bootstrap Panel Granger Causality Analysis. *Economic Insights - Trends and Challenges, 4* (67), 1-14.

Barakat, K., & Alsamara, M. (2019). The Impact of Foreign Agricultural Aid and Total Foreign Aid on Agricultural Output in African Countries. New Evidence from Panel Data Analysis. *South African Journal of Economics, 87*(3), 354-375. doi:https://doi.10.1111/saje.12224.

Benin, S., & Yu, B. (2013). *Complying with Maputo Declaration Target: Trends in public expenditures and Implications for pursuit of optimal allocation of public agricultural spending.* Washington, D.C: RESAKSS Annual Trends and Outlook Report. doi:IFPRI https://resakss.org/node/11

Berger, J., Dalheimer, B., & Brummer, B. (2021). Effects of variableEU import levies on corn price volatility. *Food Policy, 102, 102063*. doi:doi:10.1016/j.foodpol.2021.102063

Bersvendsen, T., & Ditzen, J. (2021). Testing for slope heterogeneity in Stata. *The Stata Journal (2021), 21*(1), 51-80.

Bharali, P., & Charaborty, D. (2016). The Impact of Openness on Economic Growth. *Vidyasagar University Journal of Commerce, 21*, 52-61.

Blaug, M. (1978). *Economic Theory in Retrospect.* New Delhi: Vikas Publishing House.

Blomquist, J., & Westerlund, J. (2013). Testing slope homogeneity in large panels with serial correlation. *Economics Letters, 121*, 374-378.

Bao, D. (2012). *Total Factor Productivity in Vietnamese Agriculture and Its Determinants.Unpublished PHD Thesis.* Faculty of Business and Government. University of Canbera.

Barro, R. (1991). Economic Growth in A Cross Section of Countries. *The Quarterly Journal of Economics, 106*, 407-443.

Battese, G., & Coelli, T. (1995). A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data", Empirical Economics, 20-325. 20-35.

Beck, T., & Levine, R. (2004). Stock Markets, Banks and Growth. Panel Evidence. *Journal of Economic Literature* .

Bedasa, T., & Krishnamoorthy, S. (1997). Technical Efficiency in Paddy Farms of Tamil Nadri. *The Journal of International Association of Agricultural Economists, 16* (3), 185-192.

Benhabib, J., & Spiegel, M. (2000). The Role of Financial Development in Growth and Investment. *Journal of Economic Growth, 5* (4), 341-360.

Beintema, N., & Stads, G. (2011). *African Agricultural R & D in the New Millenium, Progress for some, challenges for many.* Washington DC: International Food Policy Research Institute.

Benin, S. (2014). *How is the L'Aquila Food Security Initiative (AFSI) Doing?* Washington DC: Intertional Food Policy Research Institute (IFPRI) Discussion Paper: 1329.

Benin, S., & Yu, B. (2013). *Complying with the Maputo Declaration Target. Trends in Public Agricultural Expenditures and Implications for Pursuit of Optimal Allocation of Public Agricultural Spending.* Washington DC: International Food Policy Research Institute:

Benin, S., Johnson, M., & Ominda, B. (2010). *Monitoring and Evaluation (M & E) System for the Comprehensive Africa Agriculture Development Programme (CAADP).* Washington DC: International Food Policy Research Institute. ReSAKSS working Paper 6.

Benin, S., Nin Pratt, A., Wood, S., & Guo, G. (2011). *Trends and Special Patterns in Agricultural Productivity in Africa 1961-2010.* Washinton DC: International Food Policy Research Institute: ReSAKSS Annual Trends and Outlook Report 2011.

Binswanger, H. (1992). The impact of formal finance on the rural economy of India (English). Policy, Research working papers ; no. WPS 949. Agricultural policies. Washington, DC: World Bank.

Binswanger, H., Mundlak, Y., Yang, C., & Bowers, A. (1987). Determinants of Cross Country Agricultural supply. *Journal of Econometrics, 36*, 111-131.

Block, S. (1995). "The Recovery of Agricultural Productivity in Sub Saharan Africa" Journal of Food Policy 20(5) pp 385-405.

Bojanic, A. (2012). The impact of financial development and trade on the economic growth of Bolivia. *Journal of Applied Economics, 15* (1), 51-70.

Born, B., & Breitung, J. (2016). Testing for serial correlation in fixed-effects panel data models. *Econometric Reviews, 35*, 1290-1316.

Bose, P. (1998). Formal-Informal Sector Interaction in Rural Credit Markets. *Journal of Development Economics, 56* (10), 265-280.

Bouet, A., & Sall, L. (2021). *African Participation in Global Agricultural Trade. "In the African Agricultural Trade Monitor 2021, edited by A. Bouet, P-S Odjo, and C. Zaki, 15-48.* Washington DC: IFPRI.

Brander, J., & Krugman, P. (1983). "A Reciprocal Dumping Model of International Trade". *Journal of International Economics, 16* (3-4), 313-321.

Brander, J., & Spencer, B. (1985). "Export subsidy and International Market share rivalry". *Journal of International Economics, 18* (Nos. 1-2), 83-100.

Breitung, J. (2005). "A Parametric Approach to the estimation of cointegration vectors in panel data",. *Journal of Econometric Reviews, 24*, 151-173.

Breitung, J. (2000). "On the estimation and inference of a cointegrated regression in panel data". *Advances in Econometrics, 15*, 179-222.

Breitung, J., & Pesaran, M. (2008). Unit Roots and Cointegration in Panels. In J. Breitung, & M. Pesaran, *Unit Roots and Cointegration in Panels. The Econometrics of Panel Data* (Third ed.), pp. 279-322.

Breusch, T., & Pagan, A. (1980). The LM test and its applications to model specifications in Econometrics. *Review of Economic Studies, 47*, 239-254.

Calderon, C., & Liu, L. (2003). The direction of causality between financial development and economic growth. *Journal of Development Economics, 72*, 321-334.

Caves, D., Christensen, L., & Diewert, W. (1982). The economic theory of index numbers and the measurement of input, output and productivity. *Econometrica, 50* (60), 1393-1414.

Chaiya, C., Sikandow, S., Pinthong, P., Saqib, S., & Ali, N. (2023). The Impact of Formal Agricultural Credit on Farm Productivity and its Utilization in Khyber, Pakhfunkhwa, Pakistan. *Sustainability 2023, 15*. doi:https://doi.org/10.3390/su.15021217.

Chang, C.-C. (2023). The impact of quality of institutions on firm performance. A Global analysis. *International Review of Economics and Finance, 83*, 694-716. doi:https://doi.org/10.1016/j.iref.2022.10.002.

Chambers, R. (1988). *Applied Production Analysis. A Dual Approach.* New York: Cambridge University Press.

Charnes, A., Cooper, W., & Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units. *European Journal of Operations Research, 2*, 429-444.

Chaudhuri, S. (2001). "Interaction of Formal and Informal Credit Markets in Backward Agriculture: A Theoretical Analysis. *Indian Economic Review, 36* (2), 411-428.

Cheng, H. (2003). *Analysis of Panel Data.* Cambridge: Cambridge University Press.

Chikhuri, K. (2014). Agricultural Trade Liberalization and Economic Growth, Is there a Connection in Sub Saharan Africa? AEID. *Journal of Applied Econometrics and International Development:, 14* (1).

Chisasa, J., & Makina, D. (2013). Bank Credit and agricultural Output in South Africa. A Cobb Douglas Empirical Analysis. *International Business & Economics Research Journal (IBER), 12* (4), 387-398.

Choong, C., Yusop, Z., & Venus, L. (2005). Export Led Growth Hypothesis in Malaysia: An investigation using Bound's test. *Sunway Academic Journal, 2*, 13-22.

Christiaensen, L., Demery, L., & Kuhl, J. (2006). The Role of Agriculture in Poverty Reduction - An Empirical Perspective. *The World Bank, Policy Research Working Paper Series, 10*, pp. 1596-1813.

Christiansen, L., & Demery, L. (2007). *Down to Earth Agriculture and Poverty Reduction in Africa:Direction in Development.* Washington DC: World Bank.

Chudik, A., Mohaddes, K., Pesaran, M., & Raissi, M. (2016). Long run effects in large heterogeneous data models with cross sectionally correlated errors. In Essays in honour of Aman Ullah. In G. G.-R.-H. R.C Hill, *Advances in Econometrics* (pp. 85-135). Emerald Publishing Group.

Cock, J., Prager, S., Meinke, H., & Echeverria, R. (2022). Labour Productivity. The forgotten yield gap. *Agricultural Systems, 20*(1). doi:https://doi.org/10.1016/j.agsy.2022.103452.

Coelli, T. (1995). Recent Developments in Frontier Modelling and Efficiency Measurement. *Australian Journal of Agricultural Economics, 39*, 219-245.

Coelli, T., Prasad, R., & Battese, G. (2005). *An Introduction to Efficiency and Productivity Analysis.* New York: Springer.

Coelli, T., & Rao, D. (2005). "Total Factor Productivity Growth in Agriculture: A Malmquist Index Analysis of 93 Countries, 1980-2000,". *The Journal of the International Association of Agricultural Economists, 32* (1), 115-134.

Coelli, T. (1998). A Multistage Methodology for the solution of DEA oriented models. *Operations Research Letters, 23* (5), 143-149.

Coelli, T., Rao, D., & Battese, G. (1998). *An introduction to Efficiency and Productivity Analysis.* London: Kluwer Academic Publishers.

Collier, P. (2007). *The Bottom Billion. Why Poorest Countries are Failing and What Can be Done About It.* New York: Oxford University Press.

Constatini, L., Laio, F., Ridolfi, L., & Sciarra, C. (2023). An R&D perspective on international trade and sustainable development. *Scientific reports*, 1-14. Retrieved from https://doi.org/10.1038/s41598-023-34982-3.

Connolly, M. (2003). The dual nature of trade: Measuring its impact on imitation and growth. *Journal of Development Economics, 72*(1), 31-55. doi:https://doi.org/10.1016/S0304-3878(03)00067-1

Dalimov, R. (2009). " The Dynamics of Trade Creation and Trade Diversion Effects Under International Economic Integration",. *Current Research Journal of Economic Theory, 1* (1), 1-4.

Daniel, D., & Sama, M. (2021). The Role of Regional Integration in Agriculture Development in Cote d'Ivoire. *Ethiopian Journal of Environmental Studies and Management, 14*, 994-1008. doi:doi.https://ejesm.org/doi/v14.5.15

Darku, A., Malla, S., & Tran, K. (2012). *Sources and Measurement of Agricultural Productivity and Efficiency in Canadian Provnces. Crops and Livestock.* Alberta, Canada: Department of Economics. University of Lethbridge.

Darrat, A. (1999). "Are financial deepening and economic growth causally related? Another Look at the evidence",. *International Economic Journal, 13,* 19-35.

Dawuni, P., Mane, F., & Tahidu, O. (2021). Effects of village savings and loan association on agricultural value productivity in Northern Region of Ghana. *Agricultural Finance Review, 81*(5), 657-674. doi:https://doi.org/10.1108/AFR-02-2020-0024.

Dhaene, G., & Jochmans, K. (2015). Split-panel jackknife estimation of fixed effect models. *Review of Economic Studies, 82,* 991-1030. doi:https://doi.org/10.1093/restud/rdv007.

De Lombaerde, P., & Van, L. (2007). Regional Integration, Poverty and Social Policy. *Journal of International Policy, 7*(3), 377-383.

Demetriades, P., & Hussein, A. (1996). Does Financial Development cause economic growth? Time Series evidence from 16 countries. *Journal of Development Economics, 51*, 381-411.

De Melo, J., & Tsikata, Y. (2014). Regional Integration in Africa: Challenges and Prospects. *WIDER working Paper Series 037* .

Dhrifi, A. (2014). Financial Development and Agricultural Productivity. Evidence from African Countries. *International Centre for Business Research, 3* (1).

Diao, X., & Dorosh, P. (2007). Demand constraints on agricultural growth in East and Southern Africa. *Development Policy Review, 25* (3), 275-292.

Diewert, W. (1992). The Measurement of Productivity. *Bulletin of Economic Research, 44* (3), 98-163.

Djokoto, J. (2012). "Does Causal Relationships Exist Between External Trade and Foreign Direct Investment to Agriculture in Ghana?". *Journal of Business and Management, 7* (2), 179-193.

Djokoto, J. (2013). Openness and Agricultural Performance in Ghana. *Journal of Science and Technology*, *33*(2), 24-36.

Dilek, D. (2019). The Finance - Growth Nexus in the High Performance Asian Economies: A Bootstrap Panel Causality Analysis. *Iktisadi ve Idari Bilimler Dergisi*, *33* (2), 496-514.

Dobrinsky, R., & Markov, N. (2003). Policy Regime Change and Corporate Credit in Bulgaria: Asymmetric Supply and Demand Responses. *William Davidson Working Paper Series* .

Don , G., Cai, Y., & Newth, D. (2015). Effects of FDI on African Agriculture. *China Agricultural Economic Review, 7*(2), 167-184. doi:https://dx.doi.org/10.1108/CAER-08-2014-0080.

Dorosh, P., Wang, G., Yu, L., & Emily, S. (2011). Road Connectivity, Population and Crop Production in Sub Saharan Africa. Agricultural Economies 43(1): 9-103.

Dowrick, S., & Golley, J. (2004). Trade Openness and Growth: Who Benefits? *Oxford Review of Economic Policy, 20* (1), 38-56.

Dragan, M., & Shaik, S. (2010). *The Impact of Trade Openness on Technical Efficiency in US Agriculture.* Agribusiness and Applied Economics Report No. 660. North Dakota State University, Department of Agribusiness and Applied Economics.

Drukker, D. (2003). Testing for Serial Correlation in Linear Panel Data Models. *The Stata Journal*, *3* (2), 168-177.

Duican, E., & Pop, A. (2015). *The Implications of credit activity on economic growth in Romania.* Bucharest, Romania: Bucharest University of Economic Studies, Romania.

Dumitrescu, E., & Hurlin, C. (2012). Testing for Granger Non-Causality in Heterogenous Panels. *Journal of Economic Modelling, 29* (4), 1450-1460.

EAC. (2018). *East Africa Regional Economic Outlook.* Abidjan, Cote d'Voire: African Development Bank.

EAC. (2019). *East African Community Facts and Figures.* Abidjan, Cote d'Ivoire: African Development Bank.

EAC. (2022). East Africa Economic Outlook 2022. Supporting Climate Resilience and Just Energy Transition. (pp. 1-128). Abidjan, Cote d'Voire: Africa Development Bank.

EAC . (2000). *East African Community Facts and Figures.* Arusha, Tanzania: East African Community Secretariat.

EAC. (2015). *East Africa Regional Economic Outlook.* Abidjan, Cote d'Ivoire: African Development Bank.

EAC. (2017). *East Africa Regional Economic Outlook.* Abidjan, Cote d'Ivoire: African Development Bank.

EAC. (2018). *East Africa Regional Economic Outlook.* Abidjan, Cote d'Voire: African Development Bank.

EAC. (2010). *East African Community Facts and Figures.* Arusha, Tanzania: East African Community Secretariat.

EAC. (2012). *East African Community Facts and Figures.* Arusha: EAC Secretariat.

EAC. (2012). *East Africa Regional Economic Outlook, 2012.* Abidjan, Cote d'Voire: The African Development Bank.

EAC. (2002). *Regional Economic Outlook.* Abidjan: African Development Bank.

ECA. (2004). Economic Report on Africa. *Unlocking Africa's Trade Potential*. Abidjan, Cote d'Ivoire. African Development Bank.

Edeh, C., Eze, C., & Ugwuanyi, S. (2020). Impact of Foreign Direct Investment on agricultural sector in Nigeria (1981-2017). *African Development Review, 32*(4), 551-564. doi:https://Doi:10.1111/1467-8268.12460.

Eke, I., & Effiong, J. (2016). The Effects of Capital Accumulation on Crop Production Output in Nigeria. *International Journal of Agriculture and Earth Science, 2*(3), 62-81.

Edwards, S. (1998). "Openness, Productivity and Growth: What Do We Really Know?". *The Economic Journal, 108*, 383-398.

Ekelund, R., & Tollison, R. (1981). *Mercantilism as a rent seeking society: Economic regulation in historical perspective.* Texas: College station, Tex: Texas A & M University Press.

Elena, T., Carina, D., Ion, D., & Elena, C. (2015). DEA Applicability in assessment of Agricultural Efficiency in areas with similar Geographical Patterns. In A. a. Procedia (Ed.), *"ST 26733, International Conference on Agriculture for Life, Life for Agriculture".6*, pp. 704-711. Bucharest, Rommania: University of Agricultural Sciences and Veterinary Medicine.

Emirmahmutoglu, F., & Kose, N. (2011). "Testing for Granger causality in heterogenous mixed panels. *Journal of Economic Modelling, 28*, 870-876.

Engle, R., & Granger, G. (1987). "Cointegration and Error Correction: Representation, Estimation and Testing",. *Econometrica, 55*, 251-276.

Evans, C. (2001). Home Bias in Trade. Location or Foreign-ness? Federal Reserve Bank of Newyork, International Research, New York. *International Research* .

Evenson, R., & Gollin, D. (2003). *Crop Variety Improvement and Its Effects on Productivity.* Wallingford: CAB, International.

FAO. (2021). World Food and Agriculture. Statistical Year Book 2021. Rome, Italy: Food and Agricultural Organization. Retrieved from https://doi.org/10.4060/cb4477en

FAO. (2017). *The Future of Food and Agriculture: Trends and Challenges.* Rome: Food and Agriculture Organization of the United Nations.

FAO, WFP, & IFAD. (2012). *The State of Food Security in the World. Economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition.* ROME: FAO.

FAO. (2000). *FAOSTAT Database.* Food and Agriculture Organization. Rome, Italy: United Nations.

FAO. (2012). *FAOSTAT Database.* Food and Agriculture Organization. Rome, Italy: United Nations.

FAO. (2022). *Government expenditures in agriculture 2001 - 2020.Global and regional trends.* Rome: FAOSTAT Analytical Briefs Series No. 35.

FAO. (2022). *The State of Agricultural Commodity Markets 2022. The geography of food and agricultural trade. Policy approach for sustainable development.* Rome, Italy: Food and Agriculture Organization. doi:https://doi.org/10.4060/cc047/en

Fare, R., Grosskopf, S., Norris, M., & Zhang, Z. (1994). Productivity Growth, Technical Progress and Efficiency Change in Industrial Countries:. *American Economic Review, 84*, 66-83.

Farrel, M. (1957). The Measurement of Productive Efficiency,. *Journal of the Royal Statistical Society, Series A, 120* (3), 253-281.

Fongang, G., Kamdem, C., & Tambo, C. (2017). Does Openness Affect Manufacturing Growth in EMCCA Countries? A Panel Cointegration Analysis. *Munich Personal RePEc Archive (MPRA) Paper No. 83747* , 1-12.

Fosu, O., & Frimpong, J. (2006). An Examination of FDI Trade and Growth Relationships. *American Journal of Applied Sciences, 2* (11), 2079-2085.

Fowowe, B. (2020). The effects of financial inclusion on agricultural Productivity in Nigeria. *Journal of Economics and Development, 22*(1), 61-79. doi:DOI 10.1108/JED-11-2019-0059.

Friedman, M., & Schwartz, A. (1963). *A Monetary History of the United States, 1867-1960.* Cambridge: National Bureau of Economic Research.

Fuglie, K., & Rada, N. (2013, February). Resources, Policies and Agricultural Productivity in Sub Saharan Africa. . *ERR – 145, USA Agriculture, Economic Research service* .

Fulginiti, L., & Perrin, R. (1997). LDC Agriculture: A Non Parametric Malmquist Index Analysis. *Journal of Agricultural Economics* (53), 373-390.

Garidzirai, R., & Muzindutsi, P. (2020). A Panel ARDL analysis of the productivity of key economic sectors contributing to local economic growth in an emerging country. *Sciendo, 65*(1), 39-53. doi:https://DOI:10.2478/subboec-2020-0003

Granger, C. (1969). Investigating Causal Relations by Economic Models and Cross Spectral Methods. *Econometrica, 37* (3), 424-438.

Goldin, I. (1990). Comparative Advantage. *Theory and application to developing country agriculture (Working Paper No. 16)* .

Grant, R. (1991). The resource based theory of comparative advantage: Implications for strategy. *California Management Review, 33* (3), 114-135.

Grossman, G., & Helpman, E. (1991). *Innovation and Growth in the Global Economy.* Cambridge, MA: MIT Press.

Greene, W. (2012). *Econometric Analysis. Seventh Edition.* Prentice Hall, Upper Saddle River.

Gries, T., & Redlin, M. (2012). "Trade Openness and Economic Growth: A Panel Causality Analysis",. *Working Papers CIE 52* . Paderborn University, CIE Centre for International Economics.

Gurgul, H., & Lach, L. (2011). International Trade and Economic Growth in the Polish Economy. *3* (4), pp. 5-29.

Hadari, K. (2000). Testing for Stationarity in Heterogenous Data Panels. *Journal of Econometrics, 3* (2).

Hamdi, H., & Sbia, R. (2012). Error Correction based panel estimates of the relationship between CO2 emissions, energy use in Gulf Co operation Council Countries. *MPRA* , 1-10.

Hart, J., Miljkovic, D., & Shaik, S. (2015). The Impact of Trade Openness on Technical Efficiency in the Agricultural Sector of the European Union. *Journal of Applied Economics, 47* (10), 1230-1247.

Hassan, D. (2017). The Impact of Financial Development on Agricultural Growth. Empirical Evidence from Pakistan. *Journal of Economics, Business and Management, 12* (2).

Heckscher, E. (1919). The effect of foreign trade on the distribution of income. *Ekonomisk Tidskriff* , 497-512.

Helleiner, G. (1989). *Transnational Corporations and Foreign Direct Investment. Handbook of Development Economics.* Amsterdam: Elsevier.

Herath, H., Cao, L., & Cheng, Y. (2013). Trade Liberalization in Sri Lanka: Effects on Exports and Imports. *Sri Lankan Journal of Banking and Finance, 1* (1), 234-271.

Herzer, D. (2010). How does foreign direct investment really affect developing countries' growth? *Discussion papers, Research No. 207. Ibero America Institute for Economic Research* .

Herzer, D., Lehmann, F., & Boriss, S. (2006). Export Led growth in Chile: Assessing the Role of Export Composition in Productivity Growth. *Journal of Developing Economies, 14* (3), 306-328.

Hicks, J. (1969). *A Theory of Economic History.* Oxford: Clarendon Press.

Hodo, M. (2014). The Impact of Trade Agreements on Agricultural Sector Imports and Exports in Albania. *Journal of Educational and Social Research, 4* (4), 421-426.

Humphries, H., & Knowles, S. (1998). Does Agriculture Contribute to Economic Growth? Some Empirical Evidence. *Journal of Applied Economics, 30*, 775-781.

Hurlin, C. (2008). Testing for Granger Non-Causality in Heterogenous Panels,. *Working Papers halshs-00224434. Version 1 http://hal.inria.fr/docs/00/22/44/34/PDF/Causality_WP.pdf* .

Ibe, O. (2013). The Impact of Commercial Banks Credit to Agriculture on Agricultural Development in Nigeria. An Econometric Analysis. *International Journal of Business and technology, 3*.

IFPRI. (2016). *Agricultural Productivity in Africa. Trends, Patterns and Determinants.* Washington DC, USA: International Food Policy Research Institute.

Ijirshar, V. (2019). Impact of trade openness on economic growth among ECOWAS Countries: 1975 - 2017. *Journal of Applied Statitics, 10*(1), 75-96.

IFAD. (2013). *Annual Report 2013.* Rome, Italy: International Fund for Agricultural Development (IFAD).

Ilemona, A., & Okwanya, I. (2017). Linkages between Trade Openness, Productivity and Industrialization in Nigeria: A cointegration Test. *Journal of Research in World Economy, 8*, 50-78.

Im, K., Pesaran, M., & Shin, Y. (2003). Testing for Unit Roots in Heterogenous Panels. *Journal of Econometrics, 115* (1), 53-74.

Inoue, A., & Solon, G. (2006). A Portmanteau test for serially correlated errors in fixed effects models. *Econometric Theory, 22*, 835-851.

Irwan, S., Nor, A., & Muhammad, H. (2014). An Empirical Analysis of Exports between Malaysia and TPP Member Countries: Evidence from a Panel Cointegration (FMOLS) Model. *Journal of Modern Applied Science, 8* (6), 238-249.

Iyoha, M., & Okim, A. (2017). The Impact of Trade on Economic Growth in ECOWAS Countries: Evidence from Panel Data. *Journal of Econometrics, 108* (1), 1-24.

Jakovac, P. (2018). Causality between Energy Consumption and Economic Growth: Literature Review. *Proceedings of INTCESS 2018 - 5th International Conference on Education and Social Sciences.* Istanbul, Turkey: University of Rijeka, Faculty of Economics, Croatia.

Jamilah, I., Yusop, Z., Muzafar, S., & Lee, C. (2018). Openness and Economic Growth in Developing and OECD Countries. *International Journal of Economics and Management, 12* (2), 693-702.

Jayamaha, A., & Mula, J. (2011). Productivity and Efficiency Measurement Techniques. Identifying the Efficacy of Techniques for Financial Institutions in Developing Countries. *Journal of Emerging trends in Economics and Management Sciences, 2* (5), 454-460.

Jhingan, M. (2006). *International Economic Theory* (Third ed.). Vrinda Publications.

Jiao, J. (2014). Empirical Analysis of the relationship between Development of the rural Financial system and Rural Economic Growth. *9* (3), pp. 464-471.

Ji, Y.-B., & Lee, C. (2010). Data Envelopment Analysis. *Stata Journal*(10), 267-280.

Johansen, S. (1988). Statistical Analysis of Cointegrating Vectors. *Journal of Econometrics, 12*, 231-254.

Juodis, A., & Reese, S. (2022). The incidental parameters problem in testing for remaining cross-section correlation. *Journal of Business Economics and Statistics, 40*(3), 1-34.

Ju, J., Wu, Y., & Zeng, L. (2010). The Impact of Trade Liberalization on the Trade Balance in Developing Countries. *IMF Staff Papers, 57* (2), pp. 427-449.

Jung, J. (2020). Institutional Quality, FDI and Productivity: A Theoretical Analysis. *12*(17). doi:https://doi.org/10.3390/su.12177057.

Jung, W. (1986). Financial Development and Economic Growth. International Evidence. *Economic Development and Cultural Change, 34*, 333-346.

Kao, C. (1999). Spurious Regression and Residual Based Tests for Cointegration in Panel Data. *Journal of Econometrics, 90*, 1-44.

Kao, C., & Chiang, M. (2000). Nonstationary Panels, Panel Cointegration and Dynamic Panels. *Journal of Econometrics, 15*, 179-222.

Kar, M., Nazlioglu, S., & Agir, H. (2011). Financial development and economic growth nexus in the MENA countries: A Bootstrap Panel Granger causality analysis. *Journal of Economic Modelling, 28*, 685-693.

Karugia, J., Massawe, S., Guthiga, P., & Macharia, E. (2013). Agricultural Productivity in the EAC Region (1965-2010). *Paper Presented at the International Symposium and Exhibition on the Agricultural Development in the EAC Partner States at 50 Years of Independence.* Kampala, Uganda.

Kashi, K., & Kennedy, P. (2015). Exchange Rate Volatility and Agricultural Trade Flows: The Case of United States and OECD Countries. *Journal of International Agricultural Trade and Development, 9* (2), 211-231.

Kazungu, K. (2015). Trade Liberalization and the Structure of Production in Tanzania. *Unpublished PHD Thesis*. University of Glasglow.

Kehinde, M. (2014). Africa Regional Integration: Lessons from the European Union. In the Constitution. *A Journal of Constitutional Development, 4*(1), 54-81.

Kelly, E., Shallo, L., Geary, U., & Kinsella, A. (2012). *Application of DEA to Measure Technical Efficiency on a sample of Irish Dairy Farms.* Cork: Livestock Systems Research Department, Animal and Grassland Research Innovation Centre.

Khan, F., Salim, R., & Bloch, H. (2014). Nonparametric estimate of productivity and efficiency change in Australian Broadcare Agriculture. *Australian Journal of Agricultural and Resource Economics, 59*, 393-411.

Khumalo, S., & Asrat, T. (2015). . Trade Liberalization and Industry Productivity. A case of South Africa. University of Fort Hare, department of Economics, East London. *Biennial Conference of the Economic Society of South Africa.* London: University of Fort Hare.

Kim, S., Lim, H., & Park, D. (2022). The effect of Imports and Exports on Total Factor Productivity in Korea. *RIETI Discussion Paper Series07-E-022*. Retrieved from http://www.rieti.go.jp/en/

King, R., & Levine, R. (1993). Finance and Growth, Schumpeter might be right. *The Quarterly Journal of Economics, 108* (3), 717-737.

Kogid, M., Lily, J., Asid, R., Mulok, D., & Loganathan, N. (2011). Economic Growth and Foreign Direct Investment in Malaysia: Evidence from Empirical Testing. *International Journal Of Asian Economics and Business, 1*, 1-13.

Konya, L. (2006). Exports and Growth: Granger causality analysis on OECD countries with a panel data approach. Economic Modelling, 23(6), 978-992. *A journal of Economic Modelling, 23* (6), 978-992.

Korkomaz, S. (2015). “Impact of Bank Credits on Economic Growth and Inflation”. . *Journal of Applied Finance & Banking, 5* (1), 57-69.

Krugman, P. (1979). Increasing Returns, Monopolistic Competition and International Trade. *Journal of International Economics, 9* (4), 469-479.

Krugman, P. (1984). *"Import Promotion and Export Promotion" in - Henry Kierzkowski (Ed) Monopolistic Competition and International Trade.* Oxford: Oxford University Press.

Krugman, P., & Obstfeld, M. (1991). *International Economics. Theory and Policy* (Second ed.). New York: Harper Collins.

Krugman, P., & Obstfeld, M. (2009). *International Economics: Theory and Policy* (Vol. 8). University of California.

Kumar, P. (2018). Measuring Technical efficiency in Rice Productivity using DEA. A study of Odisha region in India. *International Journal of Rural Management, 14* (1), 1-21.

Lan, X. (2012). Theoretical and Empirical studies of Productivity Growth in the Agricultural Economies. Cases of China and the USA. *International Conference on Agricultural Productivity.* Shanghai, China: East China University of Science and Technology.

Lapple, D., Renwick , A., Cullinan, J., & Thorne, F. (2016). What drives innovation in the agricultural sector? A spatial analysis of knowlege spillovers. *Land Use Policy, 56*, 238-250. doi:doi?10.1016/j.landusepol.2016.04.032

Lee, C., & Chang, C. (2009). FDI, Financial Development and Economic Growth: International Evidence. *Journal of Applied Economics, 12* (2), 249-271.

Leontief, W. (1953). Domestic Production and Foreign Trade. The American capital position re-examined. *Procceedings of the American Philosophical Society*, *97(4)*, pp. 332-349.

Levin, A., Lin, C., & Lu, S. (2002). Unit Root Tests in Panel Data: Asymptotic and Finite Sample Properties. *Journal of Econometrics, 108* (1), 1-24.

Levine, R. (2005). Finance and Growth. In L. R, *Hand Book of Economic Growth* (Vol. 1, pp. 865-934).

Levine, R. (1997). Financial Development And Economic Growth: Views And Agenda. *Journal of Economic Literature, 35*, 688-726.

Levine, R., & Renelt, D. (1992). "A Sensitivity Analysis of Cross-Country Growth Regressions,". *American Economic Association, 82* (4), 942-963.

Li, X., & Gan, C. (2011). The welfare Impact of Microcredit on Rural Household in China. *Journal of Socio-Economics.* , 404-411.

Linder, S. (1961). *An Essay on Trade & Transformation.* New York: John Wiley.

Long, Y. (2021). Export competitiveness of agricultural products and agricultural sustainability in China. *Reg. Sustain, 2,* 203-210. doi:doi:10.1016/j.regsus.2021.09.001

Lopez, L., & Weber, S. (2017). Testing for Granger Causality in Panel data. *IRENE Working Paper 17-03*.

Lucas, R. (1988). On the Mechanics of Economic Development. *Journal of Monetary Economics, 22*, 3-42.

Maddala, G., & Wu, S. (1999). A Comparative Study of Unit Root Tests with Panel Data and New Simple test. Oxford Bulletin of Economics and Statistics, 1999, Vol. *61* (0), 631-652.

Magati, P. O., & Muthoni, N. (2012). Sectoral Productivity Awareness in Kenya. *International Journal of Business and Social Science, 3* (17), 72.

Mahadevan, R. (2004). Productivity Growth in Indian Agriculture. The Role of Globalization and Economic Reforms. . *Asia – Pacific Development Journal, 10* (2).

Malefa, R. (2020). Trade openness and economic growth in Botswana. Evidence from cointegration and error correction modelling. *Cogent Economics and Finance*, 1-22. Retrieved from https://doi.org/10.1080/23322039.2020.1783878.

Malefane, M., & Odhiambo, N. (2018). Impact of Trade Openness on Economic Growth: Empirical Evidence from South Africa. *Journal of International Economics, 71* (4), 387-416.

Mamba, E., & Ali, E. (2022). Do agricultural exports enhance agricultura (economic) growth? Lessons from ECOWAS countries. *Structural Change Economic Dynamics*, 257-267. doi:doi:10.1016/j.strueco.2022.10.003

Malmquist, S. (1953). *"Index Numbers and Indifference Surfaces." 4, 209-242.* (Vol. 4). Trabajos de Estaditica.

Marjit, S., Kar, S., & Sarkar, P. (2004). Capital Mobility and Informal Wage in a Small Economy—Two Examples. *South Asia Economic Journal, 5* (10), 261-266.

McKinnon, R. (1973). *Money and capital in economic development.* Washington, D.C: The Brookings Institution.

Megbowon, E., Saul, N., Nsikak-Abasi, E., & Oluwabunmi, P. (2019). Impact of Government Expenditureon Agricultural Productivity in South Africa. *Journal of Social Sciences and Research, 5*(12), 1734-1742.

Mellor, J. (1999). Employment Multipliers from Agricultural Growth and Poverty Reduction. *The Pakistan Development Review, 40* (5), 371-400.

Mellor, J., & Bruce, F. (1961). Role of Agriculture in Economic Development. *The American Economic Review, 51* (4), 566-593.

Mikayilov, J., Yusifov, S., & Nicat, H. (2016). Estimation of the Impacts of Non-Oil Traditional and Non-Tradtional Export Sectorson Non-Oil Export of Azerbaijan. *Academic Journal of Economic Studies, 2*(4), 77-89.

Mishkin, F. (2003). *"Financial Policies and the Prevention of Financial Crises in Emerging Market Countries," in Martin Feldstein, ed., Economic and Financial Crises in Emerging Market Countries (, 2003): 93-130.* Chicago: University of Chicago Press: Chicago.

Moghaddasi, S., Yazdani, S., & Majid, A. (2009). Regionalism and its effect on Iranian Agricultural Exports: The Case of Economic Cooperation Organization. *American Journal of Applied Sciences, 6* (7), 1380-1384.

Mohsin, S., & Abdelhak, S. (2003). Financial Development and Economic Growth. A Review and New Evidence. *Journal of African Economies, 12* (10), 89-110.

Mogues, T., Yu, B., Fan, S., & McBride, L. (2012, October). The impacts of public investment on aid for agriculture: Synthesis of the existing evidence. *ESA Working Paper No: 12-07*. Retrieved from www.fao.org/economic/esa

Montiel, P. (2003). "Development of Financial Markets and Macroeconomic Policy",. *Journal of African Economies, 12*.

Moosa, I. (1997). Testing the Long run Neutrality of Money in a Developing Economy: The Case of India. *Journal of Development Economics, 53* (1), 139-155.

Moyo, C., & Khobai, H. (2018). Trade Openness and Economic Growth in SADC countries. *Journal of Economic Literature, 71* (5).

Muhammad, S., Shabbir, S., & Butt, M. (2011). Effect of Financial Development on Agricultural Growth in Pakistan: New extensions from Bounds test to level relationships and Granger causality tests. *MPRA Paper 34162* , 1-14.

Muhammad, Z. (2014). Effects of Trade Liberalization on Exports, Imports and Trade Balance in Pakistan. *Prague Economic Papers, 27* (10), pp. 121-139.

Mulwa, M., Murithi, F., & Emrouznejad, A. (2009). Impact of Liberalization on Efficiency and Productivity of the Sugar Industry in Kenya. *Journal of Economic Studies, 36* (3), 250-264.

Mun, T. (1664). *Englands Treasure by Foreign Trade.* Hamilton: MCMaster University.

Murinde, V., & Eng, F. (1994a). Financial Restructuring and Economic Growth in Singapore. *Journal of Saving and Development, 18* (2), 225-246.

Musibau, A. (2009). Determinants of Export Performance in Developing Countries. . *Journal of International and Global economics Studies.*

Musila, J., & Yiheyis, Z. . "The impact of trade openness on growth: The case of Kenya. *Journal of Policy Modeling, 37* (2), 342-354.

Msuya, E. (2007). The impact of Foreign Direct Investment on Agricultural productivity and poverty reduction in Tanzania. *MPRA Paper No. 3671*. doi:https://mpra.ub.uni-muenchen.de/3671.

Mwangi, E., Chen, F., & Njoroge, D. (2020). Agricultural Imports, Agricultural Productivity and Economic Growth in Sub Saharan Africa. *Journal of African Trade, 7*(2), 15-28.

Myrdal, G., & Myint, H. (1984). *International Inequality and Foreign Aid in Retrospect, Pioneers in Development.* New York: Oxford University Press.

Nawaz, A. (2011). Impact of Institutional Credit on Agricultural Output. A Case Study of Pakistan. *Theoretical and Applied Economics, XVIII* (10 (565)), 99-120.

Ndulu, B., Charaborti, L., Lijane, L., Ramachandran, V., & Wolgin, J. (2007). *Challenges of African Growth. Opportunities, Constraints and Strategic Directions.* Washington D.C: World Bank.

Nejad, S., Reza, M., & Amir, M. (2018). On the Role of Credit on Agricultural Growth: An Iranian Panel Data Analysis. *AIMS Agriculture and Food* , 1-11.

Ngepah, N., & Udeagha, M. (2018). African RegionaL Trade Agreements and Intra African Trade. *Journal of Economic Integration, 33* (1), 1176-1199.

Ngobeni, E., & Muchopa, C. (2022). The Impact of Government Expenditure on Agriculture and other selected variables on the value of agricultural production in South Africa (1983-2019). A Vector Autoregressive Approach. *Economies, 10*(205). doi:https://doi.10.3390/economies10090205.

Ngong, C., Onyejiaku, C., Fonchamnyo, D., & Onwumere, J. (2021). Has bank credit really impacted on agricultural productivity in Central Africa Economic and Monetary Community? *Asian Journal of Economics and Banking*. doi:https://doi.10.1108/AJEB-12-2021-0133.

Nickell, S. (1981). Biases in dynamic models with fixed effects. *Econometrica, 49*, 1417-1426.

Nikolaos, D., & Pavlos, S. (2016). Trade Openness and Economic Growth: A Panel Cointegration and Causality Analysis for the Newest EU Countries. *Rommanian Journal of Economic Forecasting, 59*, 45-60.

Nirodha, D., Malaga, J., & Jeff, J. (2014). Trade Liberalization Effects on Agricultural production Growth: The Case of Sri Lanka. *Journal of Agricultural Economics and Development, 3* (9), 144-151.

Nkamleu, G. (2004). Productivity Growth, Technical Progress and Efficiency Change in African Agriculture. *Africa Development Review, 16*, 203-222.

Nkonya, E., Pender, J., Jagger, P., Sserenkuma, D., Kaizzi, C., & Ssali, H. (2004). *Strategies for Sustainable Land Management and Poverty Reduction in Uganda.* IFRI Research Report No. 133.

Nor, H., & Elya, N. (2016). FDI, Financial Development and Economic Growth: Panel Cointegration Analysis. *International Conference on Economics and Banking (Second ICEB, 24th - 25th May 2016),* (pp. 31-45). Malaysia.

Nishimizu, M., & Page, J. (1991). *Trade, Policy, Market Orientation and Productivity Change in Industry, Trade Theory and Economic Reform.* Oxford: Basil-Blackwell.

Nishimizu, M., & Robinson, S. (1986). *Productivity Growth in Manufacturing, Industrialization and Growth: A Comparative Analysis.* Oxford: Oxford University Press.

Nuetah, J. (2018). Global Agricultural Trade Liberalization and its implications for Sub- Saharan Africa. *AERC Research Paper 350. Working Paper Series* .

Nwosu, F. (2010). The Agricultural credit Guarantee Scheme Fund: Its Roles, Problems and Prospects in Nigeria's Quest for Agricultural Development. *Researcher, 2*, 87-90.

Nyairo, N., Kola, J., & John, S. (2010). Impacts of Agricultural Trade and Market Liberalization of Food Security in Developing Countries: A Comparative Study of Kenya and Zambia. *48th Agricultural Economists Association of South Africa (AESA) Conference*, (pp. 1-27). Cape Town, South Africa.

O' Donnel, C. (2010). . Measuring and Decomposing Agricultural Productivity and Profitability Change. *The Australian Journal of Agriculture and Resource Economics, 54*, 527-560.

Odhiambo, N. (2008). Financial development in Kenya: A dynamic test of the finance led growth hypotheses. *Journal of Economic Issues, 13*, 21-36.

Odhiambo, P., & Nyangito, H. (2003, January 26). Measuring and Analyzing Agricultural Productivity in Kenya. *A review of Approaches. KIPPRA Discussion Paper No. 26*.

Odhiambo, W., Nyangito, H., & Nzuma, J. (2004). Determinants of Agricultural Growth and Productivity in Kenya (1965-2011):*KIPPRA Discussion paper No. 34, Research and Analysis.*

Odjo, S., Traore, F., & Zaki, C. (2023). *Africa Agriculture Trade Report, 2023.* Kigali and Washington D.C: AKADEMIYA 2063 and International Food Policy Research Institute. doi:https://doi.org/10.54067/9781737916475.

OECD/FAO. (2016). *"Agriculture in Sub Saharan Africa. Prospects and challenges for the next decade", in OECD-FAO Agricultural Outlook 2016-2025.* Paris, France: OECD Publishing.

Ogada, M. (2013). Essays on Farm Technology Adoption, Technical Efficiency and Productivity in Small Holder Food crop Agriculture in Kenya. Unpublished PHD Thesis, School of Economics, Kenyatta University, Nairobi Kenya.

Ogechi, A., & Olaniyi, E. (2017). The Impact of Microfinance on Financial Inclusion in Nigeria. *Journal of Developing Areas, 51* (4), 1-16.

Ogunlesi, A. (2018). "Agricultural Productivity, Fiscal and Trade Policies Nexus in Sub-Saharan Africa: A Panel Structural Vector Error Correction Model Analysis," . *MPRA Paper 90202* .

Ohlin, B. (1933). *Inter-Regional and International Trade* (Second edition ed.). Cambridge: Havard University Press.

Ojeyinka, T., & Adegboye, A. (2017). Trade Liberalization and Economic Performance in Nigeria. Evidence from Agricultural and Manufacturing sectors. *African Journal of Economic Review, 5* (3), 1-14.

Olabisi, O., & Evan, L. (2018). Causality between Trade Openness, Foreign Direct Investment and Economic Growth. Fresh evidence from Sub Saharan African Countries. *Journal of Economic Literature, 71* (4).

Olajide, A. (2006). Empirical Analysis of agricultural Productivity Growth in Sub Saharan Africa (1961-2003). Agricultural Economics Department, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

Olaniyi, E. (2017). Back to the land: The impact of financial inclusion on agriculture in Nigeria. *Iranian Economic Review, 21* (10), 885-903.

Olatunji, A. (2019). Effect of Economic Integration on Agricultural Export Performance in Selected West African Countries. *Economies, 7*(79), 1-14. doi:doi:10.3390/economies/7030079

Olena, O. (2017). Financial System and Agricultural Growth in Ukraine. *International Scientific Days, 2016.50*, pp. 1-11. Nitra, Slovakia: Faculty of Economics and Management, Slovak University of Agriculture.

Oluwafemi, S., & Omenka, L. (2018). Impact of Credits on Agricultural Output in Nigeria. *International Journal of Economics, Commerce and Management, United Kingdom., VI* (12).

Olper, A., Curzi, D., & Raimondi, V. (2017). Imported Intermediate Inputs and Firm's Productivity Growth: Evidence from the Food Industry. *Journal of Agricultural Economics, 68*(1), 280-300. doi:doi:10.1111/1477-9522.12164

Omorokunwa, O., & Obadiaru, E. (2016). Credit Constraint and Agricultural Output in Nigeria. *Journal of Social sciences, 6* (1), 172-185.

Onafowora, O., & Owoye, A. (1998). Can Trade Liberalization Stimulate Economic Growth in Africa? *Journal of World Development, 26*, 497-506.

Onoja, J. (2017). *Financial Sector Development and Agricultural Productivity.* University of san Francisco, Digital repository. Geshke Centre. San Francisco: University of San Francisco. USF Scholarship.

Ouma, D. (2017). Intra Regional Agricultural exports in the East African Community. African Journal of Economic review. Vol 13, 31. *African Journal of Economic Review* , 13-31.

Pala, A. (2016). Which Energy Growth Hypothesis is valid in OECD Countries: Evidence from Panel Granger Causality. *International Journal of Energy Economics and Policy, 6* (1), 28-34.

Pane, O., & Patunru, A. (2022). The role of imported inputs in firm's productivity and exports. evidence from Indonesia. *Review of World economics*, 629-672. doi:https://doi.org/10.1007/s10290-022-00476-2.

Pardey, P., Craig, B., & Roseboom, J. (1997). International Productivity Patterns: Accounting for Input Quality, Infrastructure and Research. *American Journal of Agricultural Economics, 79*, 1064-1076.

Patrick, H. (1966). Financial Development and Economic Growth in Underdeveloped countries. *Journal of Economic Development*, *14* (2), 174-179.

Pedroni, P. (2004). Panel Cointegration: Asymptotic and finite sample properties of Pooled Time Series tests with an application to the PPP hypothesis. *Econometric Theory, 20* (3), 597-625.

Pesaran, M. (2004). A Simple Panel Unit Root Test in the Presence of Cross Sectional Independence. *Journal of Applied Econometrics*, *22*, 265-312.

Pesaran, M., Ullah, A., & Yamagata, T. (2008). Testing Slope Homogeneity in Large Panels. *Journal of Econometrics. , 11* (1), 105-127.

Pesaran, M. (2021). General diagnostic tests for cross-sectional dependence in panels. *Emprical Economics, 60*, 13-50.

Phillips, P., & Sul, D. (2003). Dynamic Panel Estimation and Homogeneity testing under Cross section Dependence. *Journal of Econometrics*, *6*, 217-259.

Porter, M. (1990). *The Competitive Advantage of Nations.* New York: The Free Press, A Division of MacMillan Press.

Posner, M. (1961). International Trade and Technical Change. Oxford Economic Papers, 1961, Vol 13, Issue 3, 323-341. *Oxford Economic Papers, 13* (3), pp. 323-341.

Rajan, R., & Zingales, L. (1998). Financial Dependence and Economic Growth. *The American Economic Review, 88* (3), 559-586.

Rahmiye, F., & Burhan, O. (2013). Agriculture Value Added and Economic Growth in the European Union Accession Process. *Journal of Economic Literature, 4*, 62-71.

Ricardo, D. (1817). *The Principles of Political Economy and Taxation.* London: John Murray.

Robinson, J. (1952). *The Generalization of the general theory, the rate of interest and other essays.* London: Macmillan.

Romer, P. (1990). Endogenous Technological Change. *Journal of Political Economy, 98* (5), 1071-1102.

Romer, P. (1993). Ideas and Object Gaps in Economic Development. *Journal of Monetary Economies, 32*, 543-573.

Romer, P. (1986). Increasing Returns and Long Run Growth. *Journal of Political Economy, 94* (5), 1002-1037.

Rutihinda, C. (2007). Impact of Globalization on Small and Medium firms in Tanzania. *ABR & TLC Conference Proceedings.* Hawaii, USA: http://www.cluteinstitute. com/Programs/Hawaii- 2007// Article%20293.pdf.

Sabuj, K., & Madheswaran, S. (2010). Causality Between Energy Consumption and Output Growth in Indian Cement Industry: An Application of Panel Error Correction Model. *Working Paper 238* , pp. 1-11.

Sanga, D., Ahouakan, E., & Adje, N. (2022). Institutional Quality and Labour Productivity: Evidence from Economic Community of West African States Countries. *Journal of Economic Integration, 37*(3), 540-559. doi:https://doi.org/10.11130/jei.2022.37.3.540

Saida, D., & Frikha, M. (2016). Banks and economic growth in developing countries. What about Islamic banks? *Cogent Economics and Finance, 4*, 1-26.

Sakyi, D. (2011). Economic Globalisation, Democracy and Income in Sub-Saharan Africa: A Panel Cointegration Analysis. *AEL Conference 2011, Development Economics and Policy, June 24-25*, (pp. 1-34). Berlin, Germany.

Salim, H., & Najat, N. (2017). Trade Openness and Economic Growth in East African Community (EAC) Member Countries. *Journal of Economics and Sustainable Development, 8* (20), 161-168.

Samuelson, P. (1948). International Trade and the Equalisation of Factor Prices. *Economic Journal, 58*, 163-184.

Sarker, M. (2016). Role of Banks on Agricultural Development in Bangladesh. *International Journal of Economics and Development Research.* , 010-015.

Saumya, S., & Saibal, G. (2010). Demand following and supply leading relationships. An Empirical Analysis of India. *Munich Personal RePEc Archive (MPRA)* , 1-13.

Seck, A., Aflavi, A.-N., Diagne, A., & Bamba, I. (2013). Repackaging Agricultural for Greater Impact on Agricultural Growth in Africa. *Journal of Food Security*, *1*(2), 30 - 41. doi:doi: 10.12691/jfs-1-2-4.

Seven, U., & Tumen, S. (2020). Agricultural Credits and Agricultural Productivity: Cross-Country Evidence. *Institute of Labour Economics. Discussion Paper Series. IZA DP No. 12930*.

Schultz, T. (1964). *Transforming Traditional Agriculture.* Yale University Press, New Haven Ct.

Schumpeter, J. (1912). *The Theory of Economic Development. An inquiry into Profits, Capital, Credit, Interest and the Business Cycle.* Harvard Economic studies.

Shahabinejad, V., & Akbari, A. (2010). "Measuring Agricultural Productivity Growth in Developing Eight",. *Iranian Journal of Development and Agricultural Economics, 2* (9), 326-332.

Shapouri, S., Rosen, S., Peters, M., Baquedano, F., & Allen, S. (2010). *Food security Assessment 2010-2020.* US Department of Agriculture. Washington, D.C: Economic Research Service.

Shariff, U., & Noor, Z. (2015). The Impact of Macroeconomic Variables Towards Agricultural Productivity in Malaysia. *South East Asia Journal of Contemporary Business, Economics and Law, 8* (3), 60-89.

Shaw, E. (1973). *Financial deepening in economic development.* Oxford: Oxford University Press.

Shi-Hsun, H., Yu, M., & Ching'-C, C. (2003). Analysis of Total Factor Productivity Growth in China's Agricultural Sector. *Annual General Meeting, July 27-30.* Montreal, Canada: Agricultural and Applied Economics Association.

Sial, M., Awan, M., & Waqas, M. (2011). Role of Institutional Credit on Agricultural Production: A Time Series Analysis of Pakistan. *International Journal of Economics and Finance*, *3* (10), 105-126.

Silva, D., Malaga, J., & Johnson, J. (2014). Trade Liberalization Effects on Agricultural Production Growth: The Case of Sri Lanka. *Journal of Agricultural Economics and Development, 3* (9), 144-151.

Simar, L., & Wilson, P. (2000). A general methodology for bootstrapping in non-parametric frontier models. *Journal of Applied Statistics, 27*(6), 779-802.

Simar, L., & Wilson, P. (2007). Two Stage DEA: Caveat emptor. *Journal of Productivity Analysis, 36*(2), 205-218.

Simar, L., & Wilson, P. (2011). Two Stage DEA. *Journal of Productivity Analysis, 36*(2), 205-218.

Simar, P., & Wilson, P. (2007). Estimation and inference in two stagesemi-parametric models of production process. *Journal of Econometrics*(136), 31-64.

Smith, A. (1776). *An Inquiry into the Nature and Causes of Wealth of Nations* (Third ed.). London: Clarendo Press, Oxford.

Soheila, K., & Bahman, K. (2013). The Financial Development and Agriculture Growth in Iran: ARDL Approach. *Recent Advances in Energy, Environment and Financial Planning* , 335-342.

Soko, N., Kaitibie, S., & Ratna, N. (2022). Does institutional quality affect the impact of public agricultural spending on food security in Sub-Sahran Africa and Asia. *Global food security*. doi:https://doi.org/10.1016.j.gfs.2022.100668.

Solow, R. (1979). Alternative Approaches to Macroeconomic Theory. A Partial View. *Mackintosh Lecture, 1979 Paper 335* .

Ssozi, J., Asongu, S., & Amavilah, V. (2019). The Effects of Development Aid for Agriculture in Sub -Saharan Africa. *Journal of Economic Studies, 46*(2), 284-305.

Sotamenou, J., & Negwelah, G. (2018). Impact of Free Trade on Agriculture: Evidence from Ssozi, J., Asongu, S., & Amavilah, V. (2019). The Effects of Development Aid for Agriculture in Sub -Saharan Africa. *Journal of Economic Studies, 46*(2), 284-305.

Cameroon. *Journal of Smart Economic Growth, 3* (2), 55-69.

Squalli, J., & Wilson, K. (2011, October). A new Measure of trade Openness. The world Economy. *34* (10).

Stojkoski, V., Popova, K., & Tevdovski, V. (2017). Financial Development and Growth. Panel Cointegration Evidence from South Eastern and Central Europe. *Munich Personal RePEc Archive*(No. 80802), 1-19.

Stopler, W., & Samuelson, P. (1941). "Protection & Real Wages". *Review of Economic Studies, 9* (1), 58-73.

Sulku, S. (2011). Testing the Long Run Neutrality of Money in a Developing Country: Evidence from Turkey. *Journal of Applied Economics and Business Research, 1* (2), 65-74.

Sunge, R., & Maptumo, A. (2014). The impact of intra - regional country to country bilateral trade agreements on trade flows between Zimbabwe and its SADC partners. *Journal of Economics and Sustainable Development, 5*, 111-119.

Sunde, T., Tafirenyika, B., & Adeyanju, A. (2023). Testing the impact of exports, imports and trade openness and economic growth in Namibia: Assessment using the ARDL cointegration method. *Economies, 11*(86), 1-12. Retrieved from https//doi.org/10.3390/economies11030u86

Sunge, R., & Ngepah, N. (2020). Agricultural Trade Liberalization, Regional Trade Agreements and Agricultural Technical Efficiency in Africa. *Journal of Outlook on Agriculture, 1*, 66-79.

Sunge, R., & Ngepah, N. (2019). Agricultural trade liberalization, regional trade agreements ang agricultural technical efficiency in Africa. *Outlook on Agriculture, 49*(1), 66-76. doi:https://doi.org/10.1177/0030727019870551

Sunge, R., & Ngepah, N. (2020). The Impact of Agricultural Trade Liberalization on Agricultural Total Factor Productivity Growth in Africa. *International Economic Journal, Taylor and Francis Journals, 34*(4), 571-598.

Swamy, P. (1970). Efficient inference in a random coefficient regression model",. *Econometrica, 38*, 311-323.

Tahir, M., & Khan, I. (2014). Trade Openness and Economic Growth in the Asian Region.Journal of Chinese Economic and Foreign Trade Studies.7. 136153.10.1108/JCEFTS-05-2014-0006.*Journal of Chinese Economic and Foreign Trade Studies, 7* (10), 108-136.

Takam, F., Guy, M., Cyrille, B., & Litchepah, T. (n.d.). Does Trade Openness affect manufacturing growth in EMCCA countries? A Panel Cointegration Analysis. *MPRA Paper 83747* .

Tauchmann, H. (2012). Partial Frontier Efficiency Analysis. *Stata Journal, 3*(12), 461-478.

Sotamenou, J., & Negwelah, G. (2018). Impact of Free Trade on Agriculture: Evidence from Cameroon. *Journal of Smart Economic Growth, 3* (2), 55-69.

Talukder, D. (2014). Agricultural Trade Liberalization and Price Volatility in Bangladesh and Tanzania. A Comparative Analysis. *Africanus, 44* (2), 15-32.

Tawadros, G. (2007). Testing the Hypothesis of Long Run Money Neutrality in the Middle East. *Journal of Economic Studies, 34* (1), 13-28.

Taylor, L. (1990). *Socially Relevant Policy Analysis.* Cambridge: The MIT Press.

Teweldemedhin, M., & Van Schalkwyk, H. (2010). The Impact of Trade Liberalization on South African Agricultural Productivity, African association of agricultural Economists, Third Conference, Cape Town, South Africa. Cape Town, South Africa: African Association of Agricultural Economists, Third Conference.

The World Bank. (1989). *World Development Report. Agriculture for Development.* Washington, D.C: The World Bank group.

Tibergen, J. (1962). *Shaping the World Economy*. *Suggestions for an International Economic Policy.* New York: Twentieth Century Fund.

Tolga, T., Nural, Y., Mehmet, N., & Cetin, B. (2009). Measuring Technical Efficiency. *Journal of Crop and Horticultural science* , 121-129.

Tolga, T., Nural, Y., Mehmet, N., & Cetin, B. (2009). Measuring the Technical efficiency and determinants of Efficiency of Rice Farms in Marmara region, Turkey, New Zealand. *Journal of Crop and Horticultural Science, 37:2, 121-129.*

Umoru, D., & Eboriem, M. (2013). Trade Liberalization and Industrial Growth in Nigeria. *Journal of Poverty, Investment and Development, 1* (1), 148-156.

UNCTAD 2008 Annual Report . (2008).

UNCTAD. (2018). *Key Statistics and Trends in International Trade. International Trade Rebounds.* Geneva, Switzerland: United Nations.

UNECA. (2010). *Assessing Regional Integration in Africa IV: Enhancing Intra - African Trade.* Addis Ababa, Ethiopia: United Nations Economic Commission for Africa (UNECA).

United Nations. (2017). *International Trade Statistics Yearbook: Trade by Country.* Economic and Social Affairs. New York: UN Statistics Division. Economic Statistics Branch.

United Nations. (2013). *International Trade Statistics Yearbook: Trade by Country.* New York: UN Statistics Division, Economic Statistics Branch.

United Nations. (2019). *World Population Prospects, 2019.* Department of Economic and Social Affairs (UN DESA): Population Dynamics.New York.

UN (2021). International Trade Statistics Year Book 2021. New York, USA: United Nations Statitics Division, Economic Statistics Branch. Retrieved from https://comtrade.un.org

Umaru, A., & Inusa, E. (2021). Openess and Agricultural Performance in Nigeria. *Asian Journal of Economic Modelling, 9*(2), 132-144.

UNDP. (2017). *Sustainable Development Goals.* Rome: United Nations Development Programme.

Uremadu, S., Ariwa, F., & Duru, U. (2018). Impact of Government Agricultural Expenditure on Agricultural Productivity in Nigeria. *Current Investigation in Agriculture and Current Research, 5* (3), pp. 679-688.

Valentina, H., Denis, N., & Xuan, S. (2015). “Agricultural Credit and Economic Growth in the rural areas”, Agricultural Finance Review. *75* (3), 302-312.

Valerio, A. (2014). V. Determinants of Agricultural Productivity of selected major crops in Calabarzon region, Philipines, Global Business and Economics Research Journal, 3(7): 16-31. *Global Business and Economics Research Journal, 3(7): 16-31., 3* (7), 16-31.

Vamvakidis, A. (1999). Vamvakidis A. (1999): Regional trade Agreements or Broad liberalization. Which path leads to Faster Growth? A journal of the IMF, March, 1999, Vol. 46, No 1.

Verbeek, M. (2000). *A Guide to Modern Econometrics.* Wiley, Chichester.

Vernon, R. (1966). International Investment & International Trade in the Product Cycle. *Quarterly Journal of Economics, 80* (2), 190-207.

Vinaye, A. (2009). *Assessing the SADC's potential to promote intra regional trade in agricultural goods.* University of Mauritius, Reduit.

Wanat, S., Monica, P., & Smiech, S. (2016). Insurance market development and economic growth in transition countries: Some new evidence based on Bootstrap Panel Granger Causality Test. *Munich Personal RePEc Archive (MPRA) No. 69051* , 1-18.

Weiss, J. (1992). Export Response to Trade Reform. Recent Mexican Experience. Development Policy Review. *10 (1992),* pp. 43-60.

Wieliczko, B., Kujawska, A., & Agnieszka, S. (2020). Savings of Small Farms: Their Magnitude, Determinants and Role in Sustainable Development. An Example of Poland. *Agriculture Journal, 10*(11), 1-18. doi:https://doi:10.3390/agriculture. 10110525.

Westerlund, J. (2008). Panel Cointegration Tests of the Fisher Effect. *Journal of Applied Econometrics, 23* (2), 193-233.

Wooldridge, J. (2002). *Econometric Analysis of Cross section and Panel Data.* Cambridge, MA: MIT Press.

WTO. (2022). *World Trade Statistical Review 2022.* Geneva, Switzerland: World Trade Organization.

World Bank. (2007). *The World Development Report. Main Report.* Washington D.C: The World Bank Group.

World Bank. (2013). World Development Indicators.Washington, D.C. The World Bank Group

World Bank. (2007a). World Development Report.Agriculture for Development. Washington, D.C. The World Bank group.

World Bank. (2009). *World Development Report.* Washington D.C: The World Bank Group.

World Bank. (2013). *World Development Report.* Washington, DC: The World Bank Group.

World Bank. (2016). *World Development Report.* Washington, DC: The World Bank Group.

World Bank. (1989). *World Development report. Agriculture for Development.* Washington, D.C: The World Bank Group.

World Bank. (2012). *World Development Report. The Main Report.* Washington D.C: The World Bank Group.

World Bank. (2018). *World Development Report: Agriculture for Development.* Washington, D.C: The World Bank Group.

World Bank. (2011). *World evelopmemt Report. Agriculture for Development.* Washington, D.C: The world Bank Group.

WTO. (2013). *World Trade Report 2013: Factors Shaping the future of World trade.* Geneva: WTO.

Wursten, J., & Leuven, K. (2018). Testing for serial correlation in fixed-effects panel models. *The Stata Journal, 18*(1), 76-100.

Xiao, J., Juodis, A., Karavias, Y., & Sarafidis, V. (2023). Improved tests for Granger noncausality in panel data. *The Stata Journal, 23*(1), 230-242. doi:DOI:10.1177/1536867X231162034

Yaya, K. (2017). The impact of trade openness on economic growth: The case of Cote d'Ivoire. *Journal of Economics and Finance, 5* (1).

Yazdani, S. (2008). Financial Market Development and Agricultural Economic Growth in Iran. . *Eurasian Journal of Sustainable Agriculture,, 2* (3), 338-343.

Yeboah, O., Gunden, C., Shaik, S., Allen, A., & Li, T. (2011). Measurement of Agricultural Productivity and Efficiency Gains From NAFTA. *Southern Agricultural Economics Association Meeting*, (pp. 1-13). Corpus Christi.

Yin, R. (1999). Production Efficiency and Cost Competitiveness of Pulp Producers in the Pacific Rim. *Forest Products Journal, 49,* 43-49.

Yu, B., & Nin-Pratt, A. (2011, December). Agricultural Productivity and Policies in Sub Saharan Africa. *IFPRI, Discussion paper No. 01150* .

Yusuf, E. (2015). Financial Development and Economic Growth on an Emerging Market. A Bootstrap Panel Causality Analysis.s,. *A Journal of Theoretical and Applied Economics, XXII*, 3(6), 171-186.

Zakaria, M. (2014). *Effects of Trade Liberalization on Exports, Imports and Trade Imbalance in Pakistan. A Time series Analysis. Comsats Institute of Technology, Islamabad, Pakistan.*

Zamorano, L. (2003). *Total Factor Productivity Growth, Technical Efficiency Change and Energy input: An International Frontier Analysis.* Hesling York: Department of Economics; University of York.

APPENDICES

APPENDIX 1: VRS_TE RESULTS

YEAR	BURUNDI	KENYA	RWANDA	TANZANIA	UGANDA	OVERALL
1998	1	0.96173	1	1	0.954271	0.9832002
1999	1	0.920492	0.993114	0.995555	1	0.9818322
2000	0.997754	0.977256	0.994219	0.996748	0.982179	0.9896312
2001	1	0.969322	1	1	0.959519	0.9857682
2002	0.999977	0.891298	1	1	0.945343	0.9673236
2003	0.996904	0.984626	1	1	0.929013	0.9821086
2004	1	0.919934	1	1	0.902623	0.9645114
2005	1	0.976819	0.992377	0.998186	0.927191	0.9789146
2006	1	0.944784	0.985045	0.996683	0.902019	0.9657062
2007	1	0.968218	1	1	0.908808	0.9754052
2008	1	0.931408	1	1	0.924348	0.9711512
2009	1	0.916693	0.994173	1	0.959958	0.9741648
2010	1	0.913497	0.987434	0.995003	0.959717	0.9711302
2011	1	1	0.990606	0.997967	0.954144	0.9885434
2012	1	0.939157	1	1	0.948948	0.977621
2013	1	0.963392	1	1	1	0.9926784
2014	1	1	0.991306	1	0.953468	0.9889548
2015	1	0.909480	1	0.98449	0.921685	0.963131
2016	1	0.990343	1	1	0.947131	0.9874948
2017	1	0.968027	1	0.982871	0.986866	0.9875528
2018	1	0.909938	0.999704	1	0.939630	0.901768
2019	1	0.927846	0.945763	1	0.947402	0.9160078
2020	1	1	1	1	0.919189	0.9838378
2021	1	1	1	1	1	1.000000
2022	1	0.95673	1	1	0.972459	0.9858378
MEAN	0.9997854	0.9536396	0.9949496	0.99790012	0.949836	0.979222

Source: Author's Computation from World Bank and FAO data

APPENDIX 2: CRS_TE RESULTS

YEAR	BURUNDI	KENYA	RWANDA	TANZANIA	UGANDA	OVERALL
1998	1	0.93394	0.91641	1	0.729364	0.9159428
1999	0.911196	0.846947	0.870984	0.971598	0.831849	0.8865148
2000	0.841319	0.944504	0.890584	0.982514	0.811874	0.894159
2001	1	0.90751	0.940775	1	0.767429	0.9231428
2002	0.894808	0.760224	1	1	0.714198	0.873846
2003	0.750806	0.837110	0.934736	1	0.649866	0.8345036
2004	0.903512	0.779408	0.948162	0.960011	0.594866	0.8372118
2005	0.851777	0.751679	0.893195	0.948293	0.619254	0.8128396
2006	0.763793	0.72018	0.878345	0.933389	0.570044	0.7731502
2007	0.845719	0.764735	0.950773	1	0.560706	0.8243866
2008	0.763403	0.719649	0.957853	1	0.701267	0.8284344
2009	0.799647	0.681349	0.744039	0.969433	0.669832	0.77286
2010	0.739404	0.633785	0.702968	0.87873	0.679003	0.726778
2011	0.826903	0.840424	0.721364	0.846561	0.672777	0.7816058
2012	0.896389	0.684398	0.733907	0.791669	0.680815	0.7574356
2013	0.709405	0.711115	0.7963	0.828395	0.731666	0.7553762
2014	0.862923	0.791087	0.91318	0.778713	0.650195	0.7992196
2015	0.899954	0.627195	0.981476	0.693047	0.621763	0.764687
2016	0.897005	0.735172	0.876611	0.77555	0.686912	0.7940916
2017	1	0.671294	1	0.788304	0.697267	0.831373
2018	0.861466	0.590614	0.981631	0.862674	0.680452	0.7953674
2019	0.856505	0.600276	0.810207	0.88058	0.68395	0.7663036
2020	0.913644	1	1	1	0.779931	0.938715
2021	0.892697	1	0.973215	1	0.931466	0.9594756
2022	0.955622	0.948681	1	1	0.830812	0.947023
MEAN	0.86551588	0.77925104	0.8966686	0.91557844	0.70190232	0.831777

Source: Author’s Computation from World Bank and FAO data

APPENDIX 3: SCALE EFFICIENCY RESULTS

YEAR	BURUNDI	KENYA	RWANDA	TANZANIA	UGANDA	OVERALL
1998	1	0.971105	0.91641	1	0.764316	0.9303662
1999	0.911196	0.920103	0.877023	0.975936	0.831849	0.9032214
2000	0.843213	0.966485	0.895762	0.985719	0.826605	0.9035568
2001	1	0.936231	0.940775	1	0.799805	0.9353622
2002	0.894828	0.85294	1	1	0.755491	0.9006518
2003	0.753137	0.85018	0.934736	1	0.699523	0.8475152
2004	0.903512	0.847244	0.948162	0.960011	0.659041	0.863594
2005	0.851777	0.769517	0.900056	0.950016	0.667881	0.8278494
2006	0.763793	0.762269	0.89168	0.936496	0.631964	0.7972404
2007	0.845719	0.789838	0.950773	1	0.616969	0.8406598
2008	0.763403	0.772646	0.957853	1	0.758662	0.8505128
2009	0.799647	0.743269	0.7484	0.969433	0.729024	0.7979546
2010	0.739404	0.693801	0.711914	0.883143	0.707503	0.747153
2011	0.826903	0.840424	0.728204	0.848286	0.705111	0.7897856
2012	0.896389	0.728737	0.733907	0.791669	0.717442	0.7736288
2013	0.709405	0.738137	0.7963	0.828395	0.731666	0.7607806
2014	0.862923	0.791087	0.921189	0.778713	0.681926	0.8071676
2015	0.899954	0.689619	0.981476	0.703965	0.67594	0.7901908
2016	0.897005	0.742341	0.876611	0.77555	0.725255	0.8033524
2017	1	0.693466	1	0.802042	0.706547	0.840411
2018	0.861466	0.649071	0.981922	0.862674	0.72417	0.7686738
2019	0.856505	0.646957	0.856671	0.88058	0.721921	0.7925268
2020	0.913694	1	1	1	0.848499	0.9524386
2021	0.892697	1	0.973215	1	0.931466	0.9594756
2022	0.955622	0.991587	1	1	0.854342	0.9603102
MEAN	0.865687	0.815482	0.900921	0.91730512	0.73891672	0.84577

Source: Author’s Computation from World Bank and FAO data

APPENDIX 4: NIRS_TE RESULTS

YEAR	BURUNDI	KENYA	RWANDA	TANZANIA	UGANDA	AVERAGE
1998	1	0.51183	0.988452	0.982028	0.973356	0.8911332
1999	1	0.51183	1	1	1	0.902366
2000	0.99788	0.547191	1	0.998449	0.961953	0.9010946
2001	1	0.569673	0.994461	1	1	0.9128268
2002	1	0.603716	1	0.92428	1	0.9055992
2003	0.989891	0.635796	0.971539	0.939535	1	0.9073522
2004	1	0.670236	0.961904	0.885334	1	0.9034948
2005	0.990919	0.685129	0.952861	0.873062	0.957278	0.8918498
2006	1	0.691318	0.946139	0.839684	0.934569	0.882342
2007	0.994566	0.692112	0.96266	0.832413	1	0.8963502
2008	0.985265	0.692537	0.981943	0.827785	0.800833	0.8576726
2009	0.983384	0.757761	1	0.827218	0.772814	0.9682354
2010	0.985496	0.688505	1	0.807344	0.786209	0.8535108
2011	0.981796	0.767445	0.991431	0.808478	0.775302	0.8648904
2012	1	0.674168	1	0.799914	0.801086	0.8550336
2013	1	0.671385	1	0.7844155	0.932623	0.8776847
2014	0.989357	0.661425	0.883660	0.787937	0.902034	0.8448826
2015	1	0.718236	0.837133	0.781026	0.948493	0.8569776
2016	1	1	0.765698	0.770935	1	0.9073266
2017	1	0.90013	0.747294	0.787229	1	0.8869306
2018	1	0.971751	0.729269	0.839758	0.968152	0.901768
2019	1	1	0.710716	0.869323	1	0.9160078
2020	1	0.498014	1	1	1	0.8996028
2021	1	0.544491	0.994352	1	0.94662	0.8970926
2022	1	0.560961	0.992685	1	0.929165	0.8965622
MEAN	0.99594216	0.6890256	0.936487	0.8786459	0.93561948	0.891143

Source: Author’s Computation from World Bank and FAO data

APPENDIX 5: RTS RESULTS

YEAR	BURUNDI	KENYA	RWANDA	TANZANIA	UGANDA	OVERALL
1997	DRS	DRS	CRS	CRS	DRS	CRS
1998	DRS	DRS	DRS	CRS	DRS	DRS
1999	DRS	DRS	DRS	CRS	DRS	DRS
2000	DRS	DRS	DRS	DRS	DRS	DRS
2001	DRS	DRS	DRS	CRS	DRS	DRS
2002	DRS	DRS	DRS	CRS	DRS	DRS
2003	DRS	DRS	DRS	CRS	DRS	DRS
2004	DRS	DRS	DRS	DRS	DRS	DRS
2005	DRS	DRS	DRS	DRS	DRS	DRS
2006	DRS	DRS	DRS	DRS	DRS	DRS
2007	DRS	DRS	DRS	CRS	DRS	DRS
2008	DRS	DRS	DRS	CRS	DRS	DRS
2009	DRS	DRS	DRS	DRS	DRS	DRS
2010	DRS	DRS	DRS	DRS	DRS	DRS
2011	DRS	DRS	DRS	DRS	DRS	DRS
2012	DRS	DRS	DRS	DRS	DRS	DRS
2013	DRS	DRS	DRS	DRS	DRS	DRS
2014	DRS	DRS	DRS	DRS	DRS	DRS
2015	DRS	DRS	DRS	DRS	DRS	DRS
2016	DRS	DRS	DRS	DRS	DRS	DRS
2017	DRS	DRS	DRS	DRS	DRS	DRS
2018	DRS	DRS	DRS	DRS	DRS	DRS
2019	DRS	DRS	DRS	DRS	DRS	DRS
2020	DRS	CRS	CRS	CRS	DRS	CRS
2021	DRS	CRS	DRS	CRS	DRS	DRS
2022	DRS	DRS	CRS	CRS	DRS	DRS
MEAN	DRS	DRS	DRS	DRS	DRS	DRS

Source: Author’s Computation from World Bank and FAO data

APPENDIX 6: TFPCH RESULTS

YEAR	BURUNDI	KENYA	RWANDA	TANZANIA	UGANDA	OVERALL
1998	0.9592	1.1134	1.1308	0.9501	0.9963	1.02996
1999	0.9705	0.9164	1.0808	1.0946	1.0319	1.01884
2000	1.0611	1.0293	1.0702	1.1365	1.0009	1.04958
2001	1.0306	1.0045	0.9911	0.8821	0.9887	0.9794
2002	0.8983	0.9355	0.9241	0.8177	0.9713	0.90938
2003	1.1855	1.0527	0.7849	1.0559	1.0715	1.0301
2004	1.3563	0.9341	1.4524	1.0364	1.028	1.16144
2005	0.9412	0.9211	1.088	0.9762	0.9917	0.98364
2006	0.8946	1.0513	0.7658	0.9671	1.0267	0.9411
2007	1.2941	1.1006	1.3081	1.0766	1.1713	1.19014
2008	0.9581	0.9571	1.005	0.9607	1.0015	0.97648
2009	0.8919	0.9618	0.9808	1.0268	1.0748	0.98722
2010	0.9321	1.1002	1.0268	0.9393	0.958	0.99128
2011	0.7492	1.0192	0.967	0.932	1.0525	0.94398
2012	1.1785	0.996	0.9976	0.9455	1.0181	1.02714
2013	0.8991	1.0452	1.0354	0.9559	0.931	0.97332
2014	0.9633	1.0493	1.0233	0.9963	0.8567	0.97778
2015	0.9497	1.0092	0.9678	0.8617	1.0193	0.96154
2016	1.0742	0.9468	0.9899	1.0569	1.0474	1.02304
2017	1.1574	1.0171	1.0123	1.0539	1.1914	1.08642
2018	1.0065	1.0313	1.002	1.3554	1.0007	1.07918
2019	0.9867	1.018	0.9986	1.0023	1.0327	1.00784
2020	1.0021	1.253	0.9805	0.9995	0.8965	1.02632
2021	0.988	1.0342	0.5356	0.9982	0.9700	0.9052
2022	0.933	0.9276	0.9587	0.5445	1.0285	0.87846
MEAN	1.010448	1.016996	1.0031	0.984884	1.014296	1.00555

Source: Author’s Computation from World Bank and FAO data

APPENDIX 7: TECCH RESULTS

YEAR	BURUNDI	KENYA	RWANDA	TANZANIA	UGANDA	OVERALL
1998	1.0662	1.1134	1.1039	1.0045	0.9967	1.05694
1999	1.038	0.9164	1.0808	0.976	0.7878	0.9598
2000	1.0122	1.1615	1.0702	1.1365	1.0123	1.07854
2001	0.9816	0.9954	0.9911	0.9409	1.042	0.9902
2002	0.9641	0.8564	0.9241	0.9013	0.9797	0.92512
2003	0.8642	1.0283	0.8156	0.8981	1.0167	0.92458
2004	1.3655	1.0117	1.3978	1.1373	1.0445	1.19136
2005	0.9807	1.21	1.088	1.037	1.1842	1.09998
2006	0.8873	0.9694	0.8798	0.9671	1.1131	0.96334
2007	1.1445	1.0936	1.1385	1.1384	0.9993	1.10286
2008	0.9581	1.0066	1.005	0.9441	1.0713	0.99702
2009	0.9637	0.9839	0.9738	0.9882	0.9861	0.97914
2010	0.9449	0.9543	1.0347	0.9393	0.9563	0.9659
2011	1.0036	1.0056	1.0866	1.0048	1.0064	1.0214
2012	1.0096	1.0132	1.0312	1.0132	1.0123	1.03404
2013	0.9439	0.9268	0.9867	0.9329	0.9301	0.94408
2014	1.0274	1.0493	1.0339	1.0368	1.0465	1.03878
2015	1.0093	1.0092	1.2109	1.0123	1.0111	1.05056
2016	0.968	0.9468	0.9577	0.9622	0.9589	0.95872
2017	1.0169	1.0287	1.0217	1.0177	1.0155	1.0201
2018	1.0997	1.0889	1.0324	1.1184	1.085	1.08488
2019	1.0713	1.0689	1.0129	1.0159	1.0749	1.04878
2020	0.9899	0.9934	0.9805	0.9995	0.9947	0.9916
2021	0.8668	0.9463	0.7223	0.8998	0.9199	0.87102
2022	0.7915	0.6756	0.7282	0.5776	0.8575	0.72608
MEAN	0.998756	1.002144	1.012332	0.983992	1.004112	1.009928

Source: Author’s Computation from World Bank and FAO data