UNIVERSITY FOR DEVELOPMENT STUDIES

THE DETERMINANTS OF TOTAL FACTOR PRODUCTIVITY IN GHANAIAN AGRICULTURE

ABDURAHIM MOHAMMED MUTAKA

2019

UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE

THE DETERMINANTS OF TOTAL FACTOR PRODUCTIVITY IN GHANAIAN AGRICULTURE

BY

ABDURAHIM MOHAMMED MUTAKA

MA DEVELOPMENT ECONOMICS

(UDS/MEC/0002/17)

THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS, FACULTY OF AGRIBUSINESS AND COMMUNICATION SCIENCES, UNIVERSITY FOR DEVELOPMENT STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN AGRICULTURAL ECONOMICS

OCTOBER, 2019

DECLARATION

Student

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

Candidate's Signature: …………………… Date: ………………………

Name: **Abdurahim Mohammed Mutaka**

Supervisors

We hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University for Development Studies.

Main Supervisor's Signature: …………………… Date: ………………………

Name: **Professor Samuel A. Donkoh**

Co-Supervisor's Signature: ……………………… Date: ………………………

Name: **Dr. Hamdiyah Alhassan**

Head of Department's Signature: ………………… Date: ………………………

Name: **Dr. Joseph A. Awuni**

ABSTRACT

The role of productivity in general and agricultural productivity in particular in hastening the pace of economic growth cannot be underestimated. There is an ever rising need for increases in food supply, given the incessant increases in population and a dwindling supply of farmland that can only emanate from growth in productivity rather than increases in input usage. The study examined the total factor productivity measure and the factors influencing it in Ghanaian agriculture by employing an annual time-series data at the national level over the period 1961-2014 for both crops and livestock, aggregated. Total Factor Productivity (TFP) was estimated using the Solow index technique of the conventional growth accounting method. The ARDL Bounds cointegration test was used to establish the existence of a long run relationship between the variables. The Stock-Watson's Dynamic Ordinary Least Squares (DOLS) model was employed, with the measured TFP Growth, in investigating the effect of different macroeconomic and climatic variables on the growth of agricultural Total Factor Productivity Growth (TFPG). Total factor productivity of Ghanaian agriculture grew at -3.71% over the entire study period with an annual growth rate of -0.07%. The DOLS results indicated that human capital, infrastructural development, trade openness and rainfall positively and significantly impacted on TFPG. However, Per capita income, inflation and the exchange rate significantly impacted TFP growth negatively. In effect, the results showed that policies which advance human capital development, ensure price stability, facilitate trade openness, improve infrastructural development, promote exchange rate stability and drought controlling factors; would result in a higher agricultural productivity growth in Ghana.

ACKNOWLEDGMENTS

First and foremost, Great thanks and praise goes to the Almighty Allah for seeing me through this course.

I would like to thank my supervisors, Professor Samuel A. Donkoh (my principal supervisor) and Dr. Hamdiyah Alhassan (my co-supervisor), for their professional guidance, encouragement, patience, valuable advice and help in various ways in ensuring that this thesis and the overall program become a success. Your excellent support in reading very carefully every draft, suggesting many useful ideas for revising the thesis and all the good works will forever be remembered. I appreciate!

I would also like to thank Dr. Joseph A. Awuni and all the members of the Agricultural and Resource Economics Department of the University for their support and goodwill; and for the constructive comments I received from the participants of the Department's seminar.

My heartfelt gratitude is also expressed to my parents for their understanding and support. Most of all, I would like to thank my wife and my little kids: without their understanding, patience, and love, this thesis would not be completed. Thank you for always being there for me.

Finally, I thank all my friends, especially Mr Patrick Baku of Duraqua Investment limited, and all who made my education a success; I say may the Almighty Allah bless you all.

DEDICATION

This work is dedicated to my wife, Mrs. Abdul-Rahim and my awesome kids for being with me throughout this course.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AAGDS	Accelerated Agricultural Growth & Development Strategy
ACF	Autocorrelation Function
ADC	Agricultural Development Company
ADF	Augmented Dickey-Fuller
AGRA	Alliance for a Green Revolution in Africa
AIC	Akaike Information Criterion
AR	Autoregressive
ARDL	Autoregressive Distributed Lag
ASWG	Agriculture Sector Working Group
BoG	Bank of Ghana
CAADP	Comprehensive African Agricultural Development Plan
CBFS	Cocoa Bill Financing Scheme
CIDA	Canadian International Development Agency
CRS	Constant Returns to Scale
CV	Coefficient of Variation
DCGE	Dynamic Computable General Equilibrium
DEA	Data Envelopment Analysis
DMU	Decision Making Units
DOLS	Dynamic Ordinary Least Squares
ECM	Error Correction Model/Equilibrium Correction Model
ECOWAP	Economic Community of West African State’s Agricultural Programme

ERP	Economic Recovery Programme
ERS	Economic Research Service
FAO	Food and Agricultural Organization
FAOSTAT	Food and Agricultural Organization Statistical Database
FASDEP	Food and Agricultural Sector Development Policy
FINSAP	Financial Sector Investment Programme
FMOLS	Fully Modified Ordinary Least Squares
GAA	Growth Accounting Approach
GCE	Government Consumption Expenditure
GDP	Gross Domestic Project
GFSAD	Global Food Security Support Analysis Data
GLSS	Ghana Living Standard Survey
GoG	Government of Ghana
GPRS	Growth and Poverty Reduction Strategy
GSGDA	Ghana Shared Growth and Development Agenda
GSS	Ghana Statistical Service
HQIC	Hannan-Quinn Information Criteria
IFO	International Fertilizer Association
ILO	International Labour Organization
INF	Inflation
JOFA	Jukwa, Okumanine, Fosu and Akwamsrem Project
KI	Kendrick Arithmetic Index
KPSS	Kwiatkowski-Phillips-Schmidt-Shin

LCU	Local Currency Unit
LPG	Liquefied Petroleum Gas
MDGs	Millennium Development Goals
METASIP	Medium Term Agricultural Sector Investment Plan
MoFA	Ministry of Food and Agriculture
MoFAD	Ministry of Fishery and Aquaculture Development
MLNR	Ministry of Lands and Natural Resources
ML	Maximum Likelihood
MTADP	Medium Term Agricultural Development Programme
NABCO	Nation Builders Corps
NDPC	National Development Planning Commission
NEPAD	New Partnership for Development
NGOs	Non-Governmental Organizations
OLS	Ordinary Least Squares
PACF	Partial Autocorrelation Function
PCI	Per Capita Income
PFP	Partial Factor Productivity
PJF	Planting for Food and Jobs
PP	Phillip-Perron
R&D	Research and Development
SAP	Structural Adjustment Programme
SBIC	Schwarz Bayesian Information Criterion
SFA	Stochastic Frontier Analysis

SI	Solow Index
SSA	Sub-Saharan Africa
SSE	Secondary School Enrolment
TC	Technical Change
TDI	Translog Divisia Index
TEC	Technical Efficiency Change
TFP	Total Factor Productivity
TFPG	Total Factor Productivity Growth
TTI	Theil Tornquist Index
USAID	United States AID
ZA	Zivot-Andrews

CHAPTER ONE

INTRODUCTION

1.0 Background of the study

Many African countries have survived and continue to survive on agriculture. Based on this, agriculture is deemed to be the lever of so many African countries (World Bank 2018). In Africa, according to FAO (2013), about 70% of the labour force is employed in the agriculture sector which also provides about 30% of Africa's Gross Domestic Product (GDP). Despite this, the continent still trails other continents in terms of agricultural productivity (World Bank, 2018; Fuglie and Rada, 2013). Other studies (including Fuglie & Rada, 2013; and Wik *et al*., 2008) have underscored the dwindling nature of agricultural productivity in Africa (in general) and Sub-Saharan Africa (in particular) vis-à-vis the rest of the world. Those studies noted that Sub-Saharan Africa has not witnessed a continuous increase in per capita agricultural output over the last four decades even in the abundance of labour and land. Given the abundance of labour force and its vast land, the region could have done far better in respect of improving agricultural productivity.

In the late 2000s, food riots bedevilled the likes of Haiti, Burkina Faso, Senegal, Cameroon, Mozambique and Bangladesh (Nankani, 2009). This led to the sudden development of agri-business projects by foreigners in Angola and Sudan. The anxiety about the growth in African agricultural productivity has led to the New Partnership for African Development (NEPAD) which established the Comprehensive African Agricultural Development Plan (CAADP). In an attempt to heighten effort in promoting agriculture, the World Bank in 2007 committed its annual world development report to Agriculture. Also, the Rockefeller and Gates Foundations have given massive support to the new AGRA initiative (World Bank, 2007).

In Ghana, the agricultural sector consists of four sub-sectors namely; crops, livestock, fisheries, and forestry & logging. The Food and Agriculture Ministry (MoFA) superintends over the crops (including Cocoa) and livestock sub-sectors while the Ministry of Fisheries and Aquaculture Development (MoFAD) is in charge of the fisheries sub-sector. In the same way, the Ministry of Lands and Natural Resources (MLNR) is in charge of the forestry & logging sub-sector. This study focuses on the crops and livestock subsectors, aggregated. Crop production in Ghana accounts for over 75% of total output of the sector while livestock, fishing and forestry account for less 25% (World Bank, 2018).

Agriculture is of great significance to the economy of Ghana given its immense contribution to employment, foreign exchange, government revenue, food security, producing raw materials for agro-processing industries, enlarging markets for industrial outputs and its linkages with the rest of the economy. This is in conformity with findings in economic literature which points to the role of agriculture in economic development (Johnson and Mellor, 1961; Ranis *et al.*, 1990; Delgado *et al.*, 1998; Seini, 2002; Timmer, 2002; Pingali, 2006; Mohan and Matsuda, 2013).

Because of the significance of the sector to the economy, its performance directly reflects general economic performance, ceteris paribus. Thus, overall GDP for the entire economy correspondingly expands whenever there is considerable growth in agricultural productivity and vice versa, ceteris paribus. This implies a rapid growth of agricultural production will, in no doubt, contribute significantly to industrialization and the economic development of Ghana.

According to Breisinger, *et al*. (2011), agriculture, which witnessed massive growth in the past and was historically a lead sector, with the highest share of the growth in Gross Domestic Product and employment in Ghana, has recently lost steam. The 2015 report of the Food and Agriculture Organisation (FAO) confirmed the significant role of agriculture for the economy of Ghana in terms of employment and also the dwindling fortunes of the sector. The dominance of the sector has declined sharply since the discovery of oil when the service sector began to lead the economy. The budget statement of 2019 indicates that the agricultural sector has become the least performing sector in the economy. Notwithstanding the decline in the sector's performance, the sector remains prominent in Ghana's economy and employs about 44.7 percent of the population above 15 years (GSS, 2016).

The FAO (2015) and MoFA (2016) reports indicated that agriculture in Ghana relies heavily on rainfall with undeveloped technology that makes use of hoes and cutlasses to produce almost 80 percent of the sector's total output. Despite the seeming positive prospects for Ghanaian agriculture, the sector is still largely traditional and one could argue that past governments have belittled the primacy of agriculture by not assigning the needed technocrats to develop the sector or that government policies in agriculture are not just yielding the best of results.

It is worth stating that the capability of the farm sector to feed far more people today with fairly less farmland than seven or more decades ago is only attributed to increases in agricultural productivity. Literature documents and recognizes the significant role of productivity in accelerating the pace of economic growth and ensuring food security (Johnson and Mellor, 1961: Odhiambo, *et al*., 2003). It is worth stating, therefore, that in a country's transition to contemporary economy, agriculture can play this most significant role if there is improvement in activities or events in agriculture that provides significant sources of productivity gains.

Agricultural productivity gains emanate from two sources: Input sources and non-input sources. The portion of output not explained by the traditionally measured inputs (land, labour and capital) describes TFP. There is improvement in TFP if total output growth is faster than total input growth. In other words, TFP growth (TFPG) in agriculture does not capture any input source of agricultural productivity growth. Growth in TFP signals that more output is obtained per unit of input. This draws more rewards to both producers and consumers. Conversely, a declining TFP indicates less reward to labour and an indication of deteriorating growth within an economy. Thus, TFP is deemed the most useful and revealing measure of agricultural productivity and productivity in general (Rosegrant and Evenson, 1992).

Total factor productivity in agriculture is both a necessary and sufficient requirement for the agriculture sector development and general (overall) economic growth (Desai and Namboodiri, 1998: Kannan, 2011 and Ozden, 2014). It is a necessary condition because it enables agriculture to avoid a trap into Ricardo's law of diminishing returns to which the agricultural sector is more prone. And it is also a sufficient condition because production can be increased at reduced cost per unit. Thus the lever of agricultural productivity growth is the growth in total factor productivity.

1.1 Problem Statement

Globally, economic literature captures many studies on agricultural productivity (both partial and total factor productivity) and its determinants. However, to the best of the researcher's knowledge, studies have not been conducted well enough in Ghanaian agriculture in terms of analysing agricultural productivity through identifying its sources and determinants to commensurate the significant role of agriculture. In other words the study of TFP in Ghanaian agriculture and its drivers has not been given enough attention in the empirical literature of the economic growth of Ghana. The few available researches have been undertaken at the regional or multi-firm levels using cross sectional data(e.g. Donkoh *et al*., 2014; Mohan and

Matsuda, 2013). This research seeks to undertake rigorous study on TFP at the national level with the use of annual time series data.

The economic performance of Ghana, since the mid-1980s, has been exemplified by steady and continuous growth with agriculture playing a major role in the process, (Kolavalli *et al*., 2012). However, while the sector performed creditably immediately after independence and even beyond, its pace in current times has been a bit gloomy in terms of its declining growth (MoFA, 2015). The agriculture sector recorded a growth outturn of 4.8% in 2018 compared to a growth outturn of 6.1% in 2017. The less than expected performance (declining growth) of the sector has been identified as alarming (World Bank, 2018). An immediate development challenge is to promote trends in agricultural growth and productivity. This requires knowledge of the factors that drives growth in agricultural productivity.

Ghana's economic structure has changed dramatically since the discovery and subsequent production of oil in the late 2000s. According to the 2019 mid-year budget review of Ghana, the agricultural sector share of total GDP has become less important, deteriorating from 29.8% in 2010 to 21.2% in 2017 and 19.7% in 2018 while the service and industrial sector shares of GDP are on the rise. The sector has since become the least performing sector of the economy as at 2016 while employing a whopping 53.6% of the labour force in 2013 (GSS, 2016 and Cooke *et al*., 2016). There is therefore the need to understand factors that propels growth and productivity in Ghanaian agriculture in order to effect policies that will improve agriculture to bring about reduction in poverty and structural change.

It is worth stating that, with the exclusion of cocoa, Ghana has recently become a net importer of food and agro processing products (World Bank, 2018). In addition, several concerns have been raised over the declining agricultural share of GDP and the slowdown in Ghanaian agriculture since 2011 (World Bank, 2018). Food prices, food security, and the environment could gravely be affected by slower growth in productivity as farmers would have to intensify the use of land and chemicals to produce more output. A consequence of the inability to increase productivity at an appreciable level is that Ghana's agricultural sector is not able to compete with the imports of substitute products. This calls for the need to uncover and improve upon the sources of agricultural productivity growth.

Also, in most African countries agriculture and poverty are closely related. Improvement in the productivity of agriculture is important in reducing if not eliminating poverty in rural areas and income inequality between rural and urban centres. This is so because the majority of poor (mostly rural folk) rely heavily on agriculture for their livelihood. According to the World Bank (2018), development in agriculture is twice or more effective in improving the poor than that emanating from the non-agricultural sectors. Literature points to the fact that countries that had fairly high agricultural growth rates witnessed monumental reductions in poverty and very interesting linkages with the other sectors. For example, agricultural favouring reforms in China resulting in rapid growth in the sector's output were primarily the reason for the massive reduction in rural poverty from about 53 percent in 1981 to 8 percent in 2001. Thus increasing productivity of agriculture, which culminates in income increases in the agricultural sector and lower prices of food commodities, is an enormously significant option for reducing poverty and minimizing the income gap in Ghana. In effect, agricultural growth is very important in reducing income gap and for poverty alleviation in Ghana.

From the discussions above, it is obvious that improving agricultural total factor productivity is non-negotiable in Ghana in order to survive the danger of a deteriorating agricultural production. All over the world, development of agriculture is a primary means of guaranteeing that the need of an ever rising population does not outstrip the capability to supply food.

Review by the researcher gives an indication that there has been no study that measures and explores the determinants of TFP in Ghanaian agriculture up to the recent period (1961 – 2014). A review of literature indicates that much of the scholarly work done on agricultural TFP has been focused on the advanced economies. The few available researches with focus on emerging economies of Africa are on specific factors. Cross sectional data on countries is widely used in most of these studies. And the few that have focused on estimating TFP have done so at the multi-firm or regional level. Examples include studies by Mohan *et al*. (2014), Mohan and Mashuda (2013), among others. In Ghana, few available researches in the area of agricultural TFP and its determinants have been conducted. Mohan *et al*. (2014) and Mohan and Mashuda (2013) used cross-sectional data at the regional level to measure Agricultural TFP. This study is, therefore, an extension with much emphasis on measuring agricultural TFP and analysing the trends to unravel causal factors and preferences for continuous growth in Ghanaian agriculture using annual time series data at the national level.

1.2 Research Questions

The key research question in this study is **"What are the determinants of total factor productivity in Ghanaian Agriculture?"**

The specific questions, therefore, are:

i. What is the growth rate of TFP over the study period (1961-2014)?

ii. What trend does growth in TFP in Ghanaian agriculture exhibit? and

iii. What are the drivers of agricultural TFPG in Ghana?

1.4 Research Objectives

The study aims at estimating Agricultural TFPG for Ghana and to throw more light on the probable role of macroeconomic and climatic factors in understanding agricultural TFP growth. Analysis will be directed at examining TFP growth in Ghanaian agriculture.

The main objective is to use the conventional growth accounting framework to measure TFPG in Ghana agricultural sector and to unravel its drivers for the period 1961 – 2014.

Specifically the study seeks to:

i. Estimate TFPG in Ghanaian agriculture.

ii. Analyse trends in estimated TFP growth in Ghanaian Agriculture:

iii. Examine the drivers of TFPG in Ghana's agriculture.

1.4 Justification and Relevance of the Study

The importance of agriculture to the development process of Ghana underscores the need for this research work. The current trend of agricultural production in Ghana as well as its essential role in alleviating poverty and minimizing the income gap indicates that initiatives (policies and programs) aimed at increasing agricultural TFP are extremely important in the current period. Therefore, in order to better develop those policies and programs it is desirable to undertake a study to unravel the drivers of agricultural TFP in Ghana.

The need to expand productivity in agriculture cannot be underestimated. According to Mohan*et al.* (2014), growth in agricultural productivity is critical to the economic fortunes of Ghana's rural households and the entire economy in general. They also noted that the growth in TFP in Agriculture provides the nation with the prospects of increasing the welfare of its people. Thus, growth in TFP is often regarded as the real driver of growth in an economy. Therefore, redirecting attention on the determinants of TFP in Ghanaian agriculture is essential for maintaining long-term agricultural growth and thereby improving the sector's contribution to general economic growth. This would prove to be relevant to policy makers in regulating agricultural productivity for general economic growth.

In addition, the research is aimed at filling a research gap in the Ghanaian setting by making an important and unique contribution to literature. This is done by unravelling the sources and drivers of TFP in Ghanaian agriculture. The research will focus on TFP to analyse the significance of non-conventional inputs in agriculture.

Also, Mohan and Matsuda (2013) noted that the role of TFP in examining the trends, behaviour and nature of productivity changes across crops and regions cannot be more pronounced than in the case of Ghanaian agriculture. While elementary statistics show that the share of agriculture has been declining in both national income and total employment, variations in agricultural activities still have predominant effects on the aggregate economy. This predominance can be noted in the facts that agro sector has a majority share in employment, remains a major supplier of food and goods, shapes the rural socio-economic development, and, affects food inflation and nutritional adequacy among others. In order to better appreciate the significance of agriculture for the particular objective of rural development and for the larger policy-aim of national economic development, it is imperative to understand the ways in which TFP has evolved over time and the factors determining it. The analysis of TFP not only helps to understand the macroeconomic logic behind the observed variations in agricultural output, but also motivates an understanding of several issues pertaining to agriculture such as agricultural production risks and profitability. It also has a significant bearing on the policies and interventions at various levels of Governance for achieving appreciable development level of the agricultural sector.

To the best of the researcher's awareness, there is no study yet that measures and explores the factors influencing agricultural TFP in Ghana up to the recent period. It is, nonetheless, projected that at the end of the study, the research will unravel the empirical estimates of the drivers of agricultural TFP and its contributions to the growth of Ghanaian agriculture and general economic growth. In effect the engine driving TFP and its growth in Ghanaian agriculture can be identified. This would furnish policy makers with the requisite information for the design of suitable policies that would result in higher and continuous agricultural growth. Consequently, the thesis will proffer recommendations for improving agricultural TFP in Ghana. It will enable government; Non-Governmental Organizations (NGO's) and other policy makers to make appropriate economic policies that would improve the performance of TFP in agriculture that is geared towards general economic development. The findings will give a general picture of the challenges that hinder growth of TFP in Ghanaian Agriculture for the action of various stakeholders in the sector.

Finally, the research findings could be useful to several stakeholders in the sector and beyond including the Ministry of Food and Agriculture (Ghana), agriculture related organizations, investors, individuals and other countries of the world.

1.5 Organization of the Study

The thesis is categorized into five main chapters; the first one gives the introduction which comprises the research background, problem statement, research questions, objectives and significance of the study. The second chapter is the review of literature. The third chapter outlines the methodology employed in the study. Chapter four comprises of a data analysis and discussion of results obtained, while the last chapter (chapter five) consist of conclusion and study recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The chapter appraises agricultural policies and agricultural productivity in Ghana. It also focuses on theoretical review of the measures of agricultural productivity and provides a review of empirical literature on TFP.

2.1 Overview of Agricultural Policies in Ghana

Policies relating to agriculture are not easy to be discussed in isolation, most especially when these policies have bearing on other national policies and vice versa. Nevertheless, concise outline of some major policies that are of great significance to Ghanaian agriculture are discussed in this very section.

The role of Government in Ghana's agriculture development has been far-reaching. This is mirrored in Government's programmes before and after the adoption and implementation of the Structural Adjustment Programme (SAP) in 1983. The period before the SAP witnessed series of projects initiated by the Bank of Ghana (BoG) that sought to boost the agricultural sector of the economy.

The BoG's agricultural related initiated projects included the Cocoa Bill Financing Scheme (CBFS), Grains Bill Financing Scheme (GBFS) and Grains Warehousing

Company (GWC). Shai Hills Cattle Ranch (SHCR), Agricultural Development Company (ADC), Wulugu Livestock Company (WLC), and the Jukwa, Okumanin, Fosu and Akwamsrerm (JoFA) Project were the other Bank of Ghana Agricultural related projects (BoG, 2004). Due to inept policies adopted by their management, most of the projects did not meet their desired objectives (GFSAD, 2015; BoG, 2004). The inability of those schemes in impacting significantly on productivity is an indication of Banks' poor role in directly involving in agriculture. It stands to reason that major structural changes will be needed to engineer the sector's productivity growth. These would require designing a fitting role for each of the sector's stakeholders.

Some other agriculture-focused policies since independence included SAP championed by the World Bank in the 1980s. The SAP covered diverse aspects of the Ghanaian economy including: the Financial Sector Investment Programme (FINSAP) of the early 1990s; and the Vision 2020 agenda, which oversaw the Medium Term Agricultural Development Programme (MTADP) (1991-2000). In fact, in order to secure the advances made in agriculture during the early years of SAP, GoG/World Bank jointly initiated MTADP in 1988. The MTADP was also tasked to guide the operations of MoFA. The MTADP started in 1991 and was very significant in improving the sector's performance through the implementation of a series of projects (FAO, 2014).

It is worth stating that due to unfavourable macroeconomic conditions, growth in agriculture was slow during the early 1990s. As a result, the GoG launched the Vision 2020 Document in 1995 in order to tackle the situation. The desired objectives included reducing unemployment and increasing incomes, poverty and inequality gap reduction, and an annual growth target of 4 percent. In order to later improve upon this targeted growth rate to about 6 percent, the ministry of food and agriculture initiated the Accelerated Agricultural Growth and Development Strategy (AAGDS).

The National Agricultural Research Project – NARP (1991-99), National Livestock Services Project – NLSP (1993-99), Agricultural Sub-Sector Investment Project (1994-2000), among others were implemented under MTADP. FASDEP I was a product of AAGDS (1996-2000) which immediately followed MTADP. FASDEP I was also later developed into FASDEP II (2009-15).It must be stated that the World Bank and the Canadian International Development Agency (CIDA) were crucial in developing FASDEP II. Other policies that have had massive impact on the agricultural sector included the Ghana Irrigation Policy (2010), Ghana Land Policy (1999), and Ghana Trade and Industry Policy. All these policies and strategies, developed by the National Development Planning Commission, are connected to the Economic Community of West African States' Agricultural Programme (ECOWAP), African Union's New Economic Partnership for Development (NEPAD), CAADP, and the Global Millennium Development Goals (MDGs).

Since 2009, the Food and Agriculture Sector Development Policy (FASDEP II) of Ghana has been the country's main agricultural framework (MoFA 2017). According to MoFA (2010) the implementation plan of FASDEP II is METASIP. Critical to the implementation of the METASIP is the acknowledgement of the connection between: 1. MOFA and other ministries, departments, and agencies involved in agriculture-related activities; 2. the private sector, including farmers, processors, and input suppliers; and 3. Development partners in the Agriculture Sector Working Group (ASWG) and beyond.

There has been no major program revision in the METASIP despite changes in government. This gives an indication of the general acceptance of the programme among major players in the agricultural sector. In 2017, the agricultural sector progress report indicated that MoFA executed some developmental programmes in the various sub-sectors of agriculture. Prominent among these programs is the "Planting for Food and Jobs" (PFJ) flagship programme.

The PFJ promotes the current government's vision on agriculture that seeks contribute immensely to the structural transformation of the agricultural sector and the economy at large. This campaign, according to MoFA (2018), seeks to increase agricultural productivity through motivating farmers to accept and use certified seeds and fertilizers including the practice of good agronomic practices. Increased farm incomes and job creation are the envisaged outcome of those outlined practices.

Thus, the cardinal objective of the PFJ is to modernize the sector by supplying major inputs (certified seeds and fertilizers), enhance markets accessibility, and widen farmer's access to extension services.

According to 2017 agricultural progress report, the PFJ Campaign oversaw the supply of over 4400 metric tonnes of improved seeds and 121,000 MT of subsidised fertilizers to about 201,620 smallholder farmers with farm area of 234,102.1 ha. Also, in accordance with the objectives of PFJ which acknowledges the significance of applied technology in farming practices, more demonstration farms numbering 2,534 were instituted in 2017 compared to 218 in 2016 (MOFA, 2017). A record 127,848 farmers were visited with men accounting for 58.7%.

Some key achievements were recorded under the PFJ programme: One of such is an increase in average yields of targeted crops (maize increased from 1.8 to 3.0 MT/ha, and rice from 2.7 to 4.0 MT/ha). Production of rice also shot up to 47% from 44% in 2017 and 2016 respectively. Staple crops such as roots and tubers also sustained increased growth in yield. Also, the 2017 agricultural sector progress report indicated that about 745,000 jobs were created in 2017 under the PFJ campaign. These and other remarkable outcomes captured in the 2017 progress report led to an increase in the sector's growth rate from 3% in 2016 to 8.4% in 2017 (MoFA, 2018).

2.2 Background Review: Agricultural Productivity

According to the World Bank (2018), agriculture is a fundamental source of income and employment to small-holder farmers and rural settlements across the globe. Historically, agricultural growth has been a vital ingredient for general economic growth and development. This is manifested in the linkages between the farm sector and other sectors in generating employment, income, and growth. It stands to reason that agricultural growth is an indispensable ingredient for the reduction and eradication of rural poverty and hunger in economies that are yet to achieve their broad-base growth. This is principally so in Ghana, according to Cooke *et al*. (2016), where poverty and income inequality is pronounced in the rural communities.

Specialists in development and agriculture, for some time now, have examined the major sources of agricultural productivity growth. An example is the works of Alauddin *et al*. (2005). They assert that developing economies of Africa that are struggling to grow should place more emphasis on the factors that impact significantly on agricultural productivity growth. This shows the extent to which productivity in agriculture has been and is still a critical area of focus particularly for many developing economies of Africa. According to World Bank (2018), factors such as technical change, trade openness, access to credit, relative prices of products, input usage, human capital, agricultural research and extension, market access, weather, among others are mostly considered to be the significant determinants of agricultural productivity in Africa.

As earlier mentioned, productivity growth in agriculture is a critical area of focus for any underdeveloped nation that seeks development. Increases in agricultural productivity normally transform into increased incomes for countries. This explains why growth in agricultural productivity is particularly a key area for concentrated research (Coelli & Rao, 2005; World Bank 2018).

A study by Benin (2016) indicates that focusing on higher agricultural productivity growth is the primary approach for general development of Africa. Benin's study revealed that most of the poverty stricken populations of Africa are those that draw their livelihood from farming. Therefore, designs that improve and accelerate higher agricultural productivity growth are important in reducing the menace of poverty and hunger as well as developing the continent of Africa. Conversely growth in African agriculture still trails the other emerging economies of the world (Benin, 2016).

Benin (2016) noted that between the period 1961 and 2012, agricultural productivity in Africa grew moderately. Regardless, there have been differences in the growth rates across the countries and regions particularly in total factor productivity. A related study in Kenya by Kibaara *et al*. (2009) indicated improvements in agricultural productivity in the decade prior to 2009. However this improvement was not sufficient to achieve the desired reduction in poverty and food security in Africa.

The discovery and subsequent production of oil in Ghana has resulted in a rise in the extractive sector. Conversely, there seems to be a reduction in agricultural sector growth. In over a decade, the agricultural sector recorded its lowest growth rate in 2011 (MoFA, 2015). The industrial sector, however witnessed an increased growth rate of about 41 percent in the same year. The sector has since shown some resurgence but not enough to replicate its former feat. Consequently, the agricultural share of overall GDP has declined from 29.8 percent in 2010 to 18.9 percent in 2016 (World Bank, 2018)

It is worth stating, at this point, that literature from the acceleration in development of the Asian Tigers indicates that as nations develop there is declining contribution of agriculture to GDP thus giving prominence to industry and services sectors (Benin, 2016). A study by Diao (2010) focused on the semblance of Ghana's experience to that of the Asian Tigers. His study established that Ghana's agriculture will maintain its importance over the next decade. His study also established the momentous role agriculture plays in reducing poverty in Ghana. In furtherance, the study also noted the significance of the various sectors and its linkages in fostering broad base growth.

Diao *et al*. (2007) among others also established the significant role of agriculture in developing countries principally because of the dominance of smallholder farmers in the agricultural sector. This substantiates Jeffery Sachs' statement that any developing economy that restricts its agriculture should not expect a continuous reduction in poverty (Sachs, 2006). This suggests that as population increases in Ghana, more employment is expected in agriculture. Therefore studies of this nature are necessary to direct policy in widening the scope and potentials of the agriculture sector in accommodating the rising population.

Studies on agricultural productivity are categorized into conjectural and experimental (theoretical and empirical). Theoretical framework, according to Odhiambo *et al*. (2003) describes productivity drivers more explicitly and set hypothesis for estimation while the empirical framework observes trends over time and weighs the significance of productivity promoting factors, among others, on agricultural productivity.

2.3 Theoretical Review: Measuring Total Factor Productivity

An analysis of measurements and empirical inferences pertaining to Productivity in general and agricultural productivity in particular has certain critical dimensions ranging from conceptual and methodological to data related issues which are not uniform and homogenous at both aggregated and disaggregated levels. In particular, the critical and important dimensions pertaining to empirical analysis and estimation of agricultural productivity have been an unending debate owing to cross-section of frameworks and measurement of variables. However, there is a considerable amount of consensus on broad measurement depending upon the kind of application that is undertaken for analysis.

Though the study of productivity is not specifically related to agriculture, the fundamental views of various methods of analysis have given rise to different conclusions based on the heterogeneity that are prevalent in the information and in particular the context under consideration. A seminal work by Solow (1957) and subsequently many others have exhaustively developed the fundamental literature for empirical analysis on methodological and estimation techniques. Productivity can be analysed in terms of both total and partial factor measures and the estimation can well vary across the sub-sectors and factor-use.

Measurement of agricultural productivity is sub-divided into partial and TFP measurements. Partial factor productivity (PFP) describes the ratio of output and any one of the traditionally measured inputs, typically labour or land. It is indicated in literature that PFP has a limitation of not accounting for other inputs (Odhiambo *et al*., 2003). As a result, partial factor measurements are of restricted use and are capable of misleading and misinforming the performance of a firm (Coelli *et al*., 2005). According to Kathuria *et al*. (2012), partial measures of productivity are unable to give the accurate impact of the contribution made by factors on the level of production when the proportion of factors combination (e.g., labor and capital) changes. In order to overcome the above limitations, total factor productivity is presented to measure the ratio of total output to total inputs (total output per unit of total input). Coelli *et al*. (2005) indicated that TFP estimates are more appropriate for performance measurement and firms inter and intra comparisons. According to Odhiambo *et al*. (2003), most studies of agricultural productivity have been conducted using the TFP framework.

While the partial factor productivities, which indicate the variations in agricultural output due to conventional factors (such as land, labour and capital) are of great significance in understanding the dynamics of Ghanaian agricultural sector in terms of output growth, the nonconventional factors also equally play a predominant role in explaining agricultural growth. The contribution of the nonconventional factors such as skills and technical know-how, climate, high yielding varieties, input quality, etc. in explaining the shifts in agricultural production is condensed to compose the concept of Total Factor Productivity (TFP).

Thus, as mentioned earlier, Productivity analysis is widely considered in the literature of economics simply due to its significance in economic growth. Measurement of total factor productivity (multifactor productivity) requires complex measurement procedures.

As captured in Kathuria *et al*. (2013), Dhehibi, (2015), Dhehibi *et al*. (2016) and Abukari *et al*. (2016), generally, the major approaches of measuring TFP are classified into two. These are frontier and non-frontier approaches. They are both sub-classified into parametric and non-parametric estimation approaches. The definition of the frontier differentiates the frontier and non-frontier approaches. There are two main non-frontier approaches: Production Function Approach (PFA) or Average Response Function (a parametric estimation) and Growth Accounting Equation – GAA (non-parametric estimation). Combining the two major approaches yields the semi-parametric approach.

The frontier approach constitutes Data Envelopment Analysis (DEA) method and Stochastic Frontier Analysis (SFA) method. For a given input combination, the frontier approach sets up a production frontier that matches the set of maximum attainable output levels. In addition, the frontier also integrates technical efficiency in its measurement of TFP while the non-frontier approach, on the other hand, presumes that firms are technically efficient (Kathuria *et al*., 2013; Fare *et al*., 1994). Under the frontier approach, the sources of total factor productivity growth are further divided into Technical Change (TC) and Technical Efficiency Change (TEC). Conversely, the non-frontier approaches merely construct a line of best fit using OLS (Kathuria *et al*., 2011; Dhehibi, 2015). The non-frontier approaches also consider only technical change as TFPG.

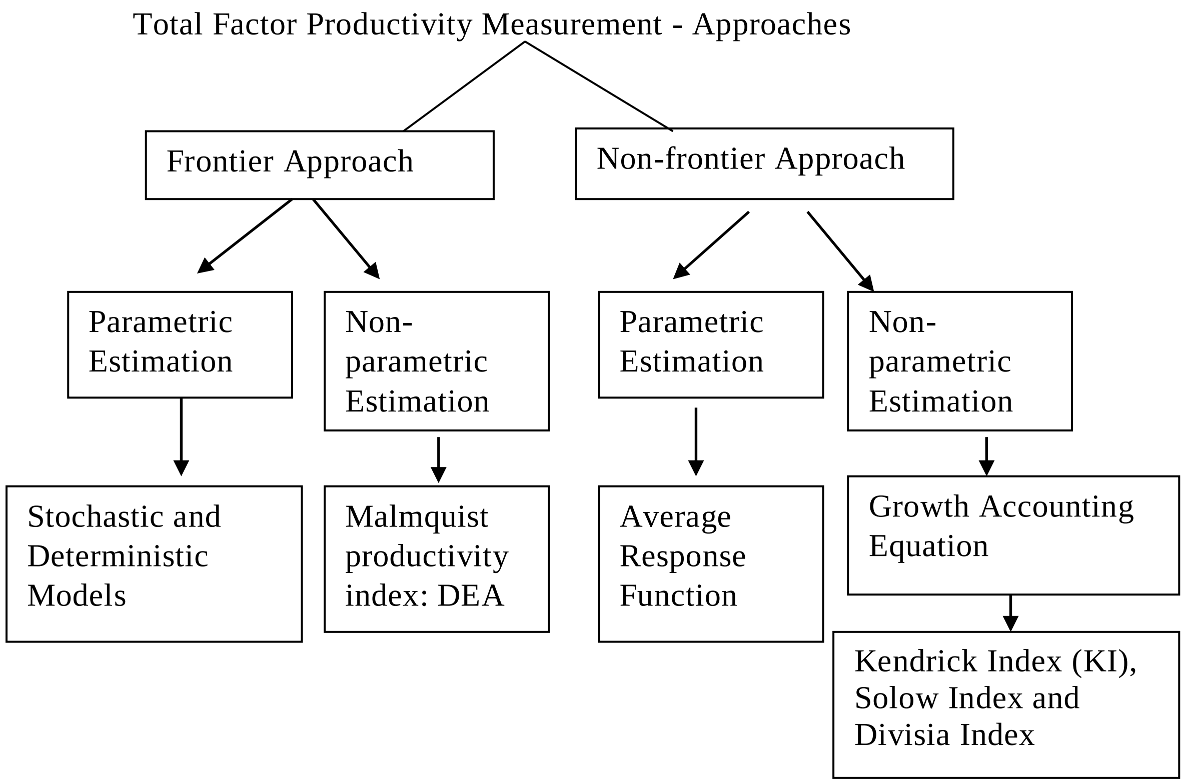

Figure 1. Approaches to the measurement of TFP: Adopted from Kathuria *et al*. (2013)

The method of estimating aggregate production function assumes that there is no technical inefficiency. Production combinations are located on the frontier and growth of total factor productivity only contains TC (Solow, 1957). According to Capalbo (1988), some other studies also added scale change into total factor productivity in this method. TC can be measured by either adding a time trend variable into the aggregate production function or using the growth accounting approach (Solow, 1957). According to Kathuria *et al*. (2013), scale change is estimated by measuring the sum of the elasticities of inputs with respect to aggregate output. The aggregate production function framework is one of the widely accepted approaches of estimating total factor productivity. It is, however, very responsive to the selection of functional format and does not also give any information about technical efficiency change (TEC) (Kathuria *et al*., 2013).

Another method that is popular in measuring productivity is the non-parametric TFP index. It measures the ratio of total output growth rate over the growth rate of all inputs employed in production. The TFP index was pioneered by Hicks (1961) and Moorsteen (1961), and later developed by Diewert (1992). The output quantity index together with the input quantity index can be estimated using the Laspeyres, Paasche, Fisher and Tornqvist formulations (Diewert, 1992). Lately, the Fisher and Tornqvist indices are widely used. The TFP index is easy to apply and as such does not require any complex estimation technique. However, the index cannot be segregated into technical change and technical efficiency change. Also, estimating the total factor productivity index requires input and output prices which are mostly unavailable.

A non-parametric approach of measuring TFP (and its segregations) is the Data Envelopment Analysis. It requires linear programming technique to measure production frontier. Production efficiency estimation using the frontier approach was first introduced by Farell (957). The term Data Envelopment Analysis originated from Charnes, Cooper and Rhodes (1978). They modeled efficiency of decision-making units (DMUs) using linear programming techniques on analysing isoquant and efficiency concepts raised by Farrell (1957). Fare *et al*. (1994) and Coelli *et al*. (2005) estimated technical efficiency on the frontier with the use of a distance function. The production frontier contains the most efficient production combinations.

Fare *et al*. (1994) introduced the Malmquist DEA to estimate total factor productivity index. In fact, this model was developed to measure Malmquist TFP index following the initiation of Caves *et al*. (1982a) by using DEA. The model segregated TFP growth into its various components (Technical Efficiency Change and Technical Change). The Malmquist DEA does not require information about output and input prices, or any specific form of production function. The model does not account for any statistical noise and is very responsive to outliers. These issues are handled by a bootstrap strategy proposed by Simar and Wilson (1998, 1999).

Stochastic Frontier Analysis (SFA) method developed by Aigner and Chu (1968) estimates a stochastic production function by decomposing the error term into random noise and technical inefficiency. Their method assumes that actual production points do not lie above the estimated production frontier, According to Aigner and Chu (1968), actual production points may fall under the production possibility curve because of random shocks in the production process or producing inefficiently).

The Stochastic Frontier Analysis method was later revised by Aigner, Lovell and Schmidt (1977), Meeusen and Van den Broeck (1977) and Battese and Coelli (1992) by adding a random error into the model to cater for the omission of relevant variables and other forms of measurement errors (Coelli *et al*., 2005). Given that the data under consideration falls under the single firm case, the researcher is unable to construct a production frontier. This puts a constraint on the use of any of the various frontier approaches and opens the door for the use of a non-frontier approach.

This current study applies the growth accounting method to measuring agricultural sector total factor productivity in Ghana. The justifications are: first and foremost, the method does not need input and output price information which is inaccessible in Ghana's context; in addition, the other estimation methods (SFA and DEA) require multiple firms (or countries) to construct a frontier and output prices as well.

The researcher further reviewed the different indices under the growth accounting approach. According to Ibrahim *et al*. (2015), the GAA uses three different indices. These include Kendrick Arithmetic Index (KI) (Kendrick, 1961), Solow geometric index (SI) (Solow, 1957) and the Theil-Tornqvist or Translog-Divisia Index (TTI), (Kathuria *et al*., 2013). The income shares of inputs are used as aggregation weights for the Kendrick Index. This is not possible with the data set since the data is devoid of the rewards for inputs. The Theil-Tornqvist Index (TTI) requires information on recent prices of inputs for estimating its weight. This enables the quality of inputs to be captured in the weights for further estimations. Kathuria *et al*. (2013) judges TTI to be better than KI and SI. However the current data cannot be used to estimate both methods (TTI and KI). Hence given the fact that the data to be used is of national character (single firm case) with no information on input prices, the SI, though with numerous assumptions (CRS, among others) is acceptable to the data. The data for this study meets all the requirements for its estimation.

The growth accounting approach provides a standard framework for evaluating the relative significance of the conventional inputs (labour and capital) and TFP growth. Thus it decomposes the growth rate of output into the growth rate of inputs (labour and capital) and the growth rate of TFP. The Cobb-Douglas production function provides the bases from which the growth accounting equation can be derived.

A recurrent research problem observed in the discourses on agricultural productivity across the academic landscape has been to associate the TFP growth to its various determinants. The residual nature of the TFP implies the complexity inherent in locating the sources of total productivity and hence poses an important challenge to any researcher in this area. The academic tools and the empirical framework including the data availability, within which the sources of TFP are modelled, critically affect the results reached by various studies. Ghanaian agriculture posits special problems in terms of data availability, irrigation infrastructure, distribution of rainfall, government policy, etc. for proper estimation of productivities in general.

2.4 Empirical Literature

Several studies, both theoretical and empirical, have examined TFP. The origin of the analysis of total factor productivity can be traced back to the seminal paper delivered by Solow in 1957. He estimated a Cobb-Douglas production function in which capital, labour and knowledge or technology determine the growth in output. Solow's growth accounting methodology has been revisited by Barro (1991), Young (1995), and Senhadji (1999) among others.

There are several empirical literatures on the significance of macroeconomic and climatic factors on the growth of agricultural productivity. However, only few have focused specifically on TFP, especially in SSA and Ghana in particular, to the best of the researcher's extensive review. Since this study is specifically on TFP, the researcher reviews previous studies devoted specifically to TFP.

Another landmark study but with reference to Indian agriculture is due to Rosegrant and Evenson (1992) who undertook an analysis of TFP growth of major crops. The paper undertook a TFP analysis of 271 districts covering 13 states in India during 1956-87. The Tornquist- Theil index 6 was used in constructing TFP index. The study used farm prices for aggregation of output and farm rental prices for aggregation of inputs as weighting factors. Comparison of TFP index estimated for India was made with estimates available for Bangladesh and Pakistan from other studies. They found that TFP grew steadily despite larger fluctuations due to weather variation, even when agricultural growth itself was growing modestly. The study found out that the main sources of productivity growth were public research, which accounted for more than 30% of variation in TFP, and domestic and foreign research and extension responsible for around 38% of TFP growth.

Desai and Namboodiri (1997) undertook an analysis of the TFP change in the Indian agriculture by analyzing the price and non-price factors affecting productivity for the period 1966-67 to 1989-90. The disintegration of output growth into input growth and TFP was done for the duration 1950-51 up to 1989-90. They used a Tornquist-Theil index for constructing a TFP index and the ratio of the indices of output and input which yields the TFP index, hence postulating TFP as a residual estimate of productivity. The authors used trans-logarithmic production function to estimate the production elasticity to aggregate inputs and construct an input index. Among the various factors determining TFP, Government expenditure on agriculture research and extension explained about 87 percent variation in TFP in the post-green revolution period covered under the study. The marginal rate of return on public investment was estimated to be over 20 percent and pointed out that there is a scope for profitable public sector participation in agro-productivity enhancing activities. It is worth noting that the study found an inverse relationship between Barter Terms of Trade (defined as the ratio of Price received by farmers to Price paid for inputs by farmers) and TFP. This was due to increased consumption expenditure following a fall in input prices as the increased real income is not spent on acquiring better know-how and training on farming skills. The study also focused on several other sources of TFP growth in the form of rural road density and the distribution of land holdings, but found them to be considerably less important than Government expenditure on R &D.

From available recent literature, studies on total factor productivity across the globe have improved massively (Wang *et al*., 2009). In the economic literature, these studies have made use of all the different approaches discussed earlier on in estimating and analysing total factor productivity.

Acemoglu (2008) investigated the factors driving the growth of total factor productivity in Turkey. He found capital (both human and physical) and institutional reforms to have a significant influence on growth. Using Malmquist indices, Rao *et al*. (2004) found TFP growth of Turkish agriculture to be 0.1 percent during the period 1970-2001. Over almost the same period, Belloumi and Matoussi (2009) indicated -1.1 percent productivity decreases in Turkey using the Malmquist productivity index technique.

In an analysis of Thai Agriculture, Suphannachart and Warr (2010) using time series data provided estimates for total factor productivity and examined the factors influencing it at an aggregate level (for both crops and livestock). The growth accounting technique together with a vector error correction modelling method were employed in the analysis. Their findings confirmed the general expectations from past studies that TFP plays a major role in output growth. The study also found that agricultural research is of great significance in impacting TFP in both the crop and livestock sub-sectors.

Avila and Evenson (2010) extensively conducted a study on TFP analysis covering Asian, African and Latin American countries. They analysed TFP using Growth Accounting method and by constructing appropriate production function from Invention-Innovation Capital Index and Technology-Mastery Index. They found that these two constructed indexes played a critical role in TFP. Although, there is a good amount of dispute on the international comparability of data, they managed to bring uniformity to some extent and have thrown light into the new dimensions of estimating technology mastery index. This study, however, suffers from a lack of country specific TFP analysis and the policy implications of the same.

Kannan (2011) estimated TFP for the state of Karnataka for ten major crops by using a crop output growth model for the years 1967-68 to 2007-08 with a CD production function. The findings indicated that trends in income and employment shares of agriculture for the state were similar to those observed at the national level. It also noted that owing to the higher level of dependency in the state agro sector for employment, the productivity gains were hindered for the major crops under consideration. The scope of the study was limited to only a single state and a regional analysis could have provided more information about productivity differentials across the Southern region of which the selected state is a part of. The study also overlooked the various possibilities of using other methods of constructing a TFP index which could have accounted for more complexity of the Productivity behaviour at a disaggregated level. An exhaustive empirical study on the sources of TFP for the chosen state could also have shed richer insights into the possibilities of enhancing productivity in the state.

Khani and Yazdani, (2012) investigated the factors influencing TFP growth of Iranian agriculture and found that a change in skilled human capital leads to 30 percent increase in TFP and 1 percent increase in physical capital yields a 55 percent increase in agricultural TFP. Mohammadrezazadeh *et al*. (2012) estimated a Translog production function over the period 1967-2008 and found TFP to grow at an average rate of 0.03 percent. Employing the Solow Residual model, Tahamipour *et al*. (2008) found agricultural total factor productivity to be increasing at the rate of 2.5% in the period 1991-2008.

Ghose and Bhattacharyya (2012) measured TFP Growth and the factors influencing it for West Bengal Agriculture using the non-parametric approach for seven major crops in West Bengal, from 1980 to 2003. The study segregated total factor productivity into the components of technical change, efficiency change, and scale change. Their analysis further revealed that public expenditure, credit, irrigation, regulated markets, and reduction in inequality in the distribution of operational land holdings to be of high significance in promoting total factor productivity growth.

Ho (2012) employed DEA and SFA to estimate TFP of Vietnam's agriculture using provincial data for the period 1990 to 2006. His finding indicated that agriculture in Vietnam is more capital intensive. Also, GDP per capita of a province, agricultural household's access to credit, agricultural population size, quality of land and size of farm were found to be significant drivers of total factor productivity. Other significant drivers of TFP were size of land plot, percentage of non-farm rural population and land fragmentation. The study also analysed the productivity convergence hypothesis of agriculture in Vietnam and concluded that provinces in the same regions with similar production conditions exhibited stronger evidence for convergence in their agricultural TFP levels.

Dev (2012) analysed key problems of Indian agriculture by undertaking an exploratory analysis of the various aspects of Indian agriculture and found retarding productivity in Indian agriculture. The author also found that among the key problems for Indian agriculture were the high disparities in State GDPs and a larger proportion of small and marginal farmers among the total number of farmers. However, the study did not account for thorough investigation of TFP and its related issues pertaining to Indian agriculture and ignored the possibility of deriving aggregate insights into the behaviour of TFP over stated period.

Chand, Kumar and Kumar (2012) demonstrated the estimation of TFP by using Tornquist-Divisia index for major crops in India for the period of 1975 to 2005. They analysed how investment in agricultural research promoted TFP across crops and it was also brought out that with increase in investment in agricultural research the real agricultural production costs felt with respect to various crops. TFP growth was found to have reduced the cost in turn in the range of 1 to 2.3 percent. The Internal Rate of Return calculated for investment on agricultural research was arrived at 42 percent and this gave good amount of scope for positive investment scenario in the Indian agriculture. The study suggested higher allocation of resources from state-monitored and funded agencies. This study did not take into account of the key variables that are responsible for productivity growth and was restricted to only aggregate investment measures.

Ali *et al*. (2012) investigated the role of some economic variables on agricultural TFP in Pakistan. With the help of time series data, they employed cointegration analysis and found education (human capital), infrastructural development, credit resources and trade openness to impact positively and significantly on agricultural TFP growth whereas inflation (macroeconomic stability) had a significant impact on TFP growth negatively. Even though the relationship was positive, Productivity growth was however not significantly affected by real per capita income. Consequently, their study concluded that policies in favour of education (improvement in human capital), credit accessibility, infrastructural development, trade openness, macroeconomic stability and improvement in real per capita income should be enhanced to improve agricultural productivity growth in Pakistan.

Mohan and Matsuda (2013) examined trends in productivity growth of some major crops in 10 regions of Ghana using panel data over the period 2000-2009. The Data Envelopment Analysis malmquist productivity indices were used in the study. Their study concluded that growth in TFP is greater in the northern region followed by Eastern and Upper West regions. Contribution of TC to total changes in productivity was found to outweigh the contribution of TEC in all regions except Eastern and Central regions.

Using growth accounting approach, Atiyas and Bakis (2013) found that TFP has been quite appreciable in the last decade than before for the Turkish economy. The study noted that higher growth in aggregate total factor productivity was responsible for the higher GDP growth in the 2000s. The result also indicated that agricultural TFP growth was relatively higher than those of industry and services sector in the last decade. The study also revealed that the 2000s was unique in the sense that it was the only decade, since the last four decades, where total factor productivity growth of agriculture was not only positive but higher than those of the other sectors.

Enu and Attah-Obeng (2013) in a study identified key factors that impacted agricultural productivity in Ghana using the OLS estimation technique with agricultural output as dependent variable. The study discovered that labour force and real GDP per capita impacted negatively on agricultural production whereas real exchange rate was found to impact agriculture positively in Ghana. The study consequently identified labour force, real exchange rate and real GDP per capita as major factors influencing agriculture in Ghana. However, the study failed to analyse total factor productivity of the agricultural sector.

Mohan *et al*. (2014) investigated the role of expenditure on agricultural research and climate change on growth of agricultural productivity on regional basis in Ghana. They employed the malmqiust index to estimate agricultural productivity growth and its decompositions. The fixed effect regression model was used to examine the factors influencing productivity growth. TFP was found to have witnessed an annual growth rate of 1.87 percent for Ghanaian agriculture over the period 1990-2009. Their study also revealed that climate variability, infrastructure, and agricultural research and development expenditure impacted positively and significantly on productivity growth of Ghanaian agriculture. Hence strengthening those factors will be of great significance to agricultural production in Ghana.

Abukari *et al*. (2015) analysed TFP growth of Turkish agriculture using the DEA malmquist productivity index and the growth accounting method. The results indicated that TFP of Turkish agriculture grew at the rate of between 19.7 percent and 37.8 percent over the study period with an annual growth rate between 1.4% and

2.7%. The authors noted that the agricultural policies of the government of the day were not fruitful enough as explained in the minimal growths in TFP within that period.

Tayebi and Fulginity, (2016) investigated the effect of climatic variables on agricultural productivity for Afghanistan, Iran, Pakistan, Turkey and Syria. Agricultural total factor productivity growth was estimated using a translog production function for the period 1980-2010. The study found positive and significant effect of temperature and precipitation on agricultural productivity whereas extreme drought impacts adversely on agricultural productivity growth in the region. Their study could have used temperatures during the growing season rather than average annual temperature which is a crude measure for the variable.

Sheng and Chancellor, (2019) undertook a study to analyse TFP and farm size and its possible determinants. Farm level data from 1989 to 2004 was used. Total factor productivity was found to be positively related to farm size. Their study demonstrated that capital outsourcing aids farmers to increase their total factor productivity and help narrow the productivity differences between various farm sizes in the grain sector.

Other studies have also applied Parametric or non-parametric distance function to estimate TFP growth. Fulginity *et al*. (2004), Bharati and Fulginiti (2007) and

Trindade and Fulginiti (2015) measured variations in efficiency performance of some countries and found life expectancy and intensity of trade to impact positively and significantly in increasing efficiency. Also, in using different parametric approaches, Headey *et al*. (2005) investigated the role of various environmental variables on total factor productivity growth rates of agriculture and discovered that agricultural scientist per thousand workers; agricultural expenditure as percentage of GDP and the real rate of assistance to agriculture have impacted positively and significantly on the TFP growth rates.

Notwithstanding the avalanche of scholarly works on total factor productivity of agriculture, it is evident that much of its focus is on developed economies of the world. A review of total factor productivity literature by the current researcher indicates that few studies are conducted on emerging economies of Africa for which Ghana is no exception. Several of these studies employ cross-sectional data to analyse agricultural productivity. Also, those few studies with focus on Africa have a persistent theme of estimating TFP at the multi-firm or regional level. In Ghana, however, little has been done in the area of agricultural TFP and its determinants. The current study measures TFP of agriculture, analyses trends and investigates factors that impacts on the agricultural TFP of Ghana using annual time series data.

CHAPTER THREE

METHODOLOGY OF THE STUDY

3.0 Introduction

The chapter focuses on the source of data gathered for the research and the various statistical and econometric techniques employed in analysing the data in order to achieve the research objectives. It looks at univariate time series modelling techniques and diagnostics checking of the estimated models. Stata 14.0 and gretl were used in the analysis with some calculation by Microsoft excel.

3.1 Data types and Sources

The study employed annual time series data ranging from 1961 to 2014. These are secondary data obtained from several sources including Ghana Statistical Service, Food and Agricultural Organization statistical database (FAOSTAT), World Bank database, International Labour Organization (ILO), International Fertilizer Association (IFA) and USAID ERS agricultural productivity tables. The data was limited to 2014 because of unavailability of data for the years following 2014. All data were converted to logarithms.

The study uses ‘traditional’ agricultural inputs in estimating TFPG. It also used macroeconomic and climatic variables that are related to the Ghanaian agriculture and may potentially impact on total factor productivity growth of the sector. These variables are GDP per capita, Inflation, Education, Trade openness, Exchange rate, Infrastructure and Rainfall.

3.2 Data Analysis

3.2.1 Objective 1: Measuring TFPG

This objective is achieved by estimating agricultural TFPG

This study adopted a non-parametric approach popularly known in productivity literature as Growth Accounting Approach (GAA) introduced by Solow (1957).Given that the data under consideration falls under a firm's category, the researcher will not be able to construct a frontier for any given year. This puts a constraint on the use of any of the various frontier approaches, as discussed in section 2.2, and opens the door for the use of a non-frontier approach. Thus a non-frontier method is most appropriate given the nature of the data set (which is without input and output prices).The study, therefore, used the GAA developed by Solow, specifically the Solow Geometric Index (SI) - one of the three different indices used under the growth accounting approach.

3.2.1.1 Theoretical Presentation

Following the seminal work by Solow, (1957)the production function was, theoretically, modified from$Y = F\ (K, L, t)$to$Y = A\ (t)\ F(K, L)$, where Y is the output, K and L denotes capital and labour inputs respectively, and the 't' represents a time trend (neutral TECH).The 'A' measures total factor productivity, while$A\ (t)$

measures growth in total factor productivity -TFPG (Solow, 1957) as captured in Abukari *et al*. (2016). A Cobb-Douglas (CD) production function is used to examine the technological association between the inputs and its resulting output. The CD production function is used in analysing the production process because it is capable of handling several inputs even with different scales of production. Even in the face of imperfections in the market, Murthy (2004) notes that, even with market imperfections, the CD function does not introduces its own distortions. Also, according to Murthy (2004), serial correlation, heteroscedasticity, multicolinearity and simultaneity are easily and well handled with a CD function.

Base on the analysis above, the sources of agricultural growth is evaluated using a CD aggregate production function (with a constant returns to scale assumption) of the form

$$Y_t = A_t F(L_t, K_t, N_t, Fert_t, Livst_t, Feed_t).$$

$$Y = AL^{\alpha} K^{\beta} N^{\gamma} Fert^{\delta} Livst^{\mu} Feed^{\pi} \qquad equation\ 3.1$$

where Y is Gross Agricultural Output in year t, L is agricultural land in hectares, K is Capital (farm machinery), agricultural Labour (N) is defined as 1000 persons economically active in agriculture, $Fert$ is synthetic fertilizer consumption (in metric tonnes nutrients), $Livst$ is the Livestock (measured in Head of Cattle-Equivalents), $Feed$ is the Animal Feed (in metric tonnes) and A denotes the technology parameter also called the "TFP" or "Solow residual". The parameters α, β, γ, δ,μ and π signify the shares of land, labour, capital fertilizer, livestock and animal-feed in output, respectively. The scale of operation is also identified by the summation of these parameters.

Regression analysis and extraction from available data are basically the two ways of estimating factor shares (Atiyas and Bakis, 2013). Regression analysis will be employed because data on factor shares is not readily available.

Linearizing (taking logarithm) or rewriting equation (3.1) in natural logarithms yields the following equation

$$\ln y = lnTFP + \alpha lnL + \beta lnK + \gamma lnN + \delta lnFert + \mu lnLivst + \pi lnFeed \quad (3.2)$$

$$TFP = e^{y-\alpha l - \beta k - \gamma n - \delta fert - \mu livst - \pi feed} \quad (3.3)$$

Variables in lower case are in natural logarithm form.

Equation 3.2 implicitly assumes a constant technology or TFP (A) after regressing $\ln Y$ on $\ln L$, $\ln K$, $\ln N$, $lnFert$, $lnLivst$ and $lnFeed$. The intercept after the regression represents$\ln A$. Regressing $equation$ 3.2 yields estimates of the share of the various production inputs in total agricultural output (Atiyas and Bakis, 2013; Abukari *et al*., 2016).

Differentiating $equation$ 3.2 with respect to time:

$$\frac{1}{y}\frac{dy}{dt} = \frac{1}{A}\frac{dA}{dt} + \alpha\frac{1}{L}\frac{dL}{dt} + \beta\frac{1}{K}\frac{dK}{dt} + \gamma\frac{1}{N}\frac{dN}{dt} + \delta\frac{1}{F}\frac{dFert}{dt} + \mu\frac{1}{Livst}\frac{dLivst}{dt} + \pi\frac{1}{Feed}\frac{dFeed}{dt} \qquad (3.4)$$

Mathematically, differentiating a logarithmic function yields the function's rate of change. In other words, $\frac{1}{y}\frac{dy}{dt}$, $\frac{1}{A}\frac{dA}{dt}$, $\frac{1}{L}\frac{dL}{dt}$, $\frac{1}{K}\frac{dK}{dt}$, $\frac{1}{N}\frac{dN}{dt}$, $\frac{1}{Fert}\frac{dFert}{dt}$, $\frac{1}{Livst}\frac{dLivst}{dt}$ and $\frac{1}{Feed}\frac{dFeed}{dt}$ denote the growth rate of Y, total factor productivity (A), labour (N), capital (K), land (L), fertilizer (Fert), Livestock and Animal feed respectively. For simplicity of analysis, let G_Y, G_A, G_L, G_K, G_N, G_{Fert}, G_{Livst} and G_{Feed} define output growth rate, TFP (A), labour, capital, land, fertilizer, Livestock and Animal feed respectively, as follows:

$$G_Y = G_A + \alpha G_L + \beta G_K + \gamma G_N + \delta G_{Fert} + \mu G_{Livst} + \pi G_{Feed} \qquad (3.5)$$

$$G_A = G_Y - \alpha G_L - \beta G_K - \gamma G_N - \delta G_{Fert} - \mu G_{Livst} - \pi G_{Feed} \qquad (3.6)$$

Since the variables in equation 3.4 are in natural logs, the growth rates (the G's) are estimated by deducting previous year's value from current year's value. The resultant G_A from the analysis yields total factor productivity growth per annum (Abukari *et al*., 2016). Stated differently, according to Atiyas and Bakis (2013), the intercept value emanating from regressing agricultural output on the inputs used defines the average percentage growth in total factor productivity per annum. Multiplying the G_A by the series (say

54 as in this study) results in total factor productivity growth for the entire period of study (Abukari *et al*., 2016).

The calculation of the growth rates discussed above is demonstrated as follows:

$$\frac{1}{y}\frac{\mathrm{dy}}{dt} = lnY_t - lnY_{t-1} = G_Y \qquad (3.7)$$

Following the classification of Diewert and Nakamura (2006),Atiyas and Bakis (2013), Sethi and Kaur (2013), Ibrahim *et al*. (2015) and Abukari *et al*. (2016), TFP over time becomes

$$TFP_t = \frac{Y_t}{X_t} = A_t \qquad (3.8)$$

Where X_t is aggregated input at time t.

TFP growth is then estimated as below:

$$TFPG = \left(\frac{Y_t}{X_t}\right) / \left(\frac{Y_{t-1}}{X_{t-1}}\right) = \left(\frac{A_t}{A_{t-1}}\right) \qquad (3.9)$$

3.2.1.2 Description of Variables in the section

The section describes the variables used to achieve objective one as below.

1. **Gross Agricultural Output (Constant 2004-2006 in Int'l$1000):**It represent the total volume of agricultural production for each year relative to the base period (2004 to 2006). It aggregates the production value of 189 crops and livestock commodities, valued at constant prices (2004-2006) and measured in international dollars. Data was sourced from FAOSTAT.

2. **Agricultural Land (Ag Land):** It represents total land devoted to agriculture in hectares of "rain-fed cropland equivalents." It is measured in 1000 Ha of Rain-fed Cropland Equivalents (Rain-fed Cropland, Irrigated Cropland and Pasture, weighted by relative quality). Data on this was gotten from USAID ERS agricultural productivity tables. It is represented as 'L'.

3. **Agricultural/Farm machinery:** It represents farm machinery in "40-CV tractor equivalents" (CV=metric horsepower), aggregating the number of 2-wheel tractors, 4-wheel tractors, and combine-harvesters. Data on this was extracted from USAID ERS agricultural productivity tables. It is represented as 'K'.

4. **Agricultural Labour:** Agricultural labour consists of the number of economically active adults engaged in agricultural activities for a living in Ghana. Agricultural labour is defined as 1000 persons economically active in agriculture, +15 yrs, male + female. The data is sourced from FAO database. It is represented in the study as 'N'

5. **Fertilizer (Synthetic fertilizer consumption):** It represents Metric tonnes of Nitrogen (N), Phosphorous (P_2O_5), and Potassium (K_2O) fertilizer consumption. The data was obtained from the International Fertilizer Association (IFA) database.

6. **Livestock:** It represents the total livestock capital on farms in cattle equivalents. It is measured in Head of Cattle-Equivalents (Hayami-Ruttan weights by animal size). The data is sourced from USAID ERS agricultural productivity tables.

7. **Animal Feed (in metric tonnes):** This input complement livestock in the provision of agricultural output especially protein related products. It represents the total quantity of animal feed from crops and its residues. Data was derived from the FAO commodity balance sheets.

3.2.2 Objective 2: Trend Analysis

This section looks at the trend of the estimated agricultural TFPG and it determinants. The trend of a series depicts the long term growth or decline of the time series over time. A time series variable may exhibit different type of trends; the linear, quadratic, linear constant growth and quadratic constant growth trend models among others. This study estimates these four different trend models for the TFPG, from which the best model for the growth will be selected. The best Model is the one with least Akaike Information Criteria (AIC), Schwarz Baysian Information Criterion (SBIC) and Hannan-Quinn Information Criterion (HQIC).

A time trend in a time series is a linear function of time t, if the model is given by;

$$TFPG_t = \alpha_0 + \alpha_1 t + u_t \quad (3.10)$$

If the series exhibit quadratic trends, the model is given as;

$$TFPG_t = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + u_t \quad (3.11)$$

If the trend has a constant growth form, the model is given as;

$$TFPG_t = \alpha_0 e^{\alpha_1 t} u_t \quad (3.12)$$

and for a quadratic constant growth, the logarithmic form of the model is given as;

$$\ln TFPG_t = \ln\alpha_0 + \alpha_1 t + \alpha_2 t^2 + \ln u_t \quad (3.13)$$

where $TFPG_t$ is the actual value at time t, $t = 1, \ldots, T$, u_t is the error term and α_0, α_1, α_2 are the regression coefficients of regression of the actual values on time.

The trend analysis is carried out to understand and predict variables and their future movements.

3.2.3 Objective 3: Factors Influencing TFPG in Ghanaian Agriculture

The methodology employed in achieving objective three of the study is specified in this particular segment. It specifies the model to estimate the factors influencing agricultural TFPG in Ghana. It comprises of two sub-segments: 3.2.3.1 specifies the model; and 3.2.3.2 defines variables used in the model

3.2.3.1 Model specification

This section seeks to estimate the impact of several macroeconomic and weather variables on agricultural TFPG. The model specified incorporates TFPG, measured in this study, as the dependent variable. The determinants are independent variables selected from literature review and deemed to have impact on TFPG. The researcher opts to analyse agricultural TFPG and its determinants using an approach similar to that of Coe *et al*. (1997), Miller and Upadhyay (2000), Ozden (2014), Suphannachart and Warr (2012) and Ali *et al*. (2012) where TFPG is regressed on independent variables that are perceived to impact TFP growth. The independent variables include the following macroeconomic and climatic variable: GDP per capita, Inflation, Education, Trade openness, Exchange rate, Infrastructure and Rainfall.

Based on the estimated results in section 3.2 of this Chapter, measuring agricultural TFP growth, this section gives a model to investigate the factors influencing agricultural TFP in Ghana. Consequently the relationship between macroeconomic and climatic variables on TFPG is examined by the specification:

$$TFPG = f(LPCI, LINF, LSSE, \ln\_trade, l\_excRate, LGCE, \ln\_RFL)$$

$$TFPG_t = C + \beta_1 LPCI_t + \beta_2 LSSE_t + \beta_3 LINF_t + \beta_4 \ln\_trade_t + \beta_5 \text{l\_excRate}_t + \beta_6 LGCE_t + \beta_7 \ln\_RFL_t + \varepsilon_t \qquad (3.14)$$

Where;

$$TFPG = \text{Total Factor Productivity } Growth$$

$$LPCI \quad = \text{log of real per capita income (GDP Per Capita)}$$

$LSSE$ = log of secondary school enrolment (proxy for education/human capital)

$LINF$ = log of inflation rate (indicator for macroeconomic stability)

$$\ln\_trade$$

$$= \text{log of trade as a \% of GDP (proxy for openness of agricultural economy)}$$

$l\_excRate$ = log of real exchange rate

$$LGCE = \text{log of general government final consumption expenditure}$$

$$LRFL \quad = \text{log of rainfall } (proxy\ for\ climate)$$

3.2.3.2 Definition of variables

The dependent variable of the model (TFPG) was already described in detail in section 3.2.1. The researcher defines the independent variables of the model in this section. The variables are discussed below.

1. **Per capita income - GDP per capita (constant LCU)):** It describes the effect of average income per head on total factor productivity growth (Ho, 2012). Income per head used in the study describes the effect of income level on agricultural productivity growth. Higher level of income per capita (sign of economic growth) is expected to translate into more capital accumulation and technological investment and a wider market for agricultural products. The data was sourced from the World Bank Database.

2. **Education and training (Human Capital Development):** A well trained and educated population is expected to impact positively on agricultural productivity. Education and training improves the skills and potentials of labour as an input of production. Pasha *et al*. (2002) captured the role of primary and secondary education in productivity growth. Secondary school enrolment was used as an indicator variable by Akinlo (2005) and Njikam *et al*. (2006) to capture the role of education on total factor productivity. Enrolment at the secondary school is also used in this current study to demonstrate the role of education and human capital on TFP growth. The data was sourced from the World Bank Database.

3. **Inflation:** It captures the role of high and unstable prices on TFP growth of agriculture. Akinlo (2005) and Ali *et al*. (2012) used inflation as an indicator variable for macroeconomic stability to measure its impact on TFPG. This study uses inflation (annual %) as one of the indicators of macroeconomic stability. A direct relationship is expected between inflation and TFPG signalling that inflation may add to economic growth by generating employment. Conversely, inflation may also impact TFP negatively. The inverse relationship may be due to the fact that inflation promotes capital flight and create uncertainties in the economy that daunts investment. Data was derived from the World Bank database.

4. **Openness of Agricultural economy or Trade Openness (Trade as a percentage of GDP):** Trade represents the effect of trade liberalization on agricultural production. Openness of an economy to trade aids economies of scale by widening market size.

Economies of scale result in reductions in per unit cost, consequently leading to increased productivity. Ali *et al.* (2012) used agricultural trade (sum of exports and imports) as a percentage of agricultural GDP as an indicator for trade openness. The present study used 'trade (sum of exports and imports) as a percentage of GDP' as a proxy for openness of an agricultural economy. It was obtained from World Bank Database.

5. **The real exchange rate** is used to examine the impact of the value of a country's currency on TFPG of agriculture. The study expects a negative association between the two variables (exchange rate and TFPG) in Ghanaian agriculture. This is because a reduction in the value of the domestic currency (Ghana Cedi) will result in a higher cost of importing agricultural machinery and other inputs. This will consequently increase cost of production and hence impact negatively on agricultural productivity (Diallo, 2013). The data is the official exchange rate (LCU per US$, period average) obtained from the World Bank Database.

6. **Infrastructural Development (Government expenditure on infrastructure):** Infrastructure is commonly captured in literature to be a significant factor affecting total factor productivity. Rao *et al*. (2004) used government expenditure as a proxy for infrastructural development. For want of a better variable, this study used general government final consumption expenditure (current LCU) as a proxy for Infrastructural Development. The research expects higher consumption expenditure to impact positively

on total factor productivity growth of agriculture. The data was sourced from the World Bank Database.

7. **Rainfall** is used in this study as an indicator of climate variation to determine its impact on agricultural TFPG in Ghana. Rainfall measures the average annual rainfall in the country which is measured in millimetres. It is expected to influence agricultural TFPG positively in Ghana because agriculture in Ghana depends heavily on the amount and distribution of rainfall (MoFA, 2018). The data is captured from FAOSTAT.

3.3. Econometric Estimation Procedure

Since estimating equation 3.11 involves time series data, the study submits the econometric estimation procedure of the model in this section.

i. Stationarity testing (Testing for unit root)

ii. Testing for Cointegration

iii. Fitting DOLS

iv. Diagnostic Test

3.3.1 Stationarity testing (Testing for unit root)

Unit Root Test is used to examine the stationarity or otherwise of the variables under study. This test is carried out to avoid spurious regressions and the bias of OLS. Gujarati (2009) pointed out that time series data are mostly not stationary. This means that the mean, variance and covariance of such a data set are not time invariant. In fact, in an empirical analysis using time series data, it is essential to establish the presence or otherwise of unit root in the individual series being studied. The presence or absence of unit roots helps to identify the nature of the processes that generates the time series data and to investigate the order of integration of a series. This is because, contemporary econometrics has indicated that, regression analysis using non-stationary time series variables produce spurious regression since standard results of OLS do not hold (Gujarati, 2009 and Green, 2000). A variable is described to be covariance or weakly stationary if the first two moments of the series; the mean and the auto-covariance are finite and are time invariant. Thus, $E(r_t) = E(r_{t-l}) = \mu$ which is a constant and $cov(r_t, r_{t-l}) = \gamma_l$ which depends only on the lag l but not on time, t.

Following the discussions above, all the determinants are subjected to stationarity test with the help of the Augmented Dickey Fuller (ADF) test developed by Dickey and Fuller (1979) and Phillips–Perron (PP) test by Phillips-Perron (1998) that is widely employed in most studies. According to Kwakwa and Alhassan, (2018), both ADF and PP test have similar null-hypothesis of unit root or non-stationary variables and the alternate hypothesis of no unit root or stationary variables. Not rejecting the null hypothesis at levels will require differencing the series until stationarity is attained. Also, stationarity (absence of unit root) implies that the time series wonder about a constant mean with finite variance that is independent of time.

There are several quantitative techniques, both formal and informal, of subjecting time series variables to unit root or stationarity testing. Graphical inspection of the series is an informal approach that depicts the nature of the series. In graphical form, a time series plot which does not show a mean reversion gives an indication of unit roots or non-stationarity. Also a slow decaying Autocorrelation Function (ACF) plots also gives an indication of non-stationary series. The quantitative methods used in this research are; ADF test, the PP test and the Zivot-Andrews (ZA) test.

3.3.1a Augmented Dickey Fuller (ADF) Unit Root Test

This study employed the Augmented Dickey-Fuller (ADF) test to determine whether the individual variables contained a unit root (non-stationary) or were covariance stationary. The ADF test proposed by Dickey and Fuller (1979) is an upgraded form of the Dickey-Fuller (DF) test. This test is based on the assumption that the series follow a random walk with model;

$$R_t = \Phi r_{t-1} + u_t \qquad (3.15)$$

and tests the hypothesis:

$H_0 : \Phi = 1$ (Non − stationary) against

$H_1 : \Phi < 1$(Stationary)

where Φ is the characteristic root of an AR polynomial and u_t is an uncorrelated white noise series with zero mean and constant variance σ^2. When $\Phi_1 = 1$, equation (3.15) does not satisfy the weakly stationary condition of an AR (1) model hence the series becomes a random walk model known as a unit root or non-stationary time series. Subtracting $r_{t-1}$from both sides of equation (3.15) we have

$$\Delta R_t = \varphi r_{t-1} + u_t, \quad t = (1, \ldots\ldots, T) \quad (3.16)$$

where $\varphi = \Phi - 1$, and $\Delta R_t = r_t - r_{t-1}$. For estimating the existence of unit roots using equation (3.16), we test hypothesis $H_0 : \varphi = 0$ against$H_1 : \varphi \neq 0$. Under H_0, if $\varphi = 0$, then $\Phi = 1$, thus the series is non-stationary. The rejection or otherwise of the null hypothesis, H_0 is based on the t-statistic critical values of the Dickey Fuller statistic. The Dickey Fuller test assumes that the error terms are serially uncorrelated; however, the errors terms of the Dickey Fuller test do show evidence of serial correlation. Therefore, the proposed ADF test includes the lags of the first difference series in the regression equation to make u_t a white noise. The Dickey and Fuller's (1979) new regression equation is given by;

$$\Delta R_t = \varphi r_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta r_{t-j} + u_t, \quad t = (1, \ldots\ldots, T) \quad (3.17)$$

If the intercept and time trend $(\beta + \alpha t)$ are included, then equation (3.17) is written as;

$$\Delta R_t = \beta + \alpha t + \varphi r_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta r_{t-j} + u_t, \quad t = (1, \ldots\ldots, T) \quad (3.18)$$

where β is an intercept, α defines the coefficient of the time trend factor, $\sum_{j=1}^{p} \gamma_j \Delta r_{t-j}$ defines the sum of the lagged values of the response variable ΔR_t and p is the order of the autoregressive process. If φ of the Augmented Dickey Fuller model is zero (0), then there exist a unit root in the time series variable considered, hence the series is not covariance stationary. The choice of the starting augmentation order depends on the periodicity of the data, the significance of γ_i estimates and the white noise residuals series u_t. The ADF test statistic is given by;

$$F_\tau = {}^{\hat{\varphi}}\!/_{SE(\hat{\varphi})} \tag{3.19}$$

where $\hat{\varphi}$is the estimate of φ and $SE(\hat{\varphi})$ is the standard error of the least square estimate of $\hat{\varphi}$. The null hypothesis (H_0) is rejected if, the $p - value < \alpha$ (significance level). If the series is not stationary, it is transformed by differencing to make it stationary and stationarity tested again. If the time series is not stationary but its first difference is stationary, then the series is said to be an integrated process of order one (1) or simply an $I(1)$ process.

3.3.1b Phillip-Perron (Phillip and Perron, 1988) Unit Root Test

Even though the Augmented Dickey-Fuller test includes lags of the first difference of the variable to correct for serial correlation of the residual term, the problem of conditional heteroscedasticity in the residuals may still create a problem. Phillips (1987) therefore proposed an approach that corrects the original ADF unit root test to allow for a wide class of time series with heterogeneously and serially correlated errors. The Phillips and Perron (1988) semi-parametric approach for testing for the presence of unit root is an extension of the Phillips (1987) approach non-parametrically. The PP statistics test the pair of hypothesis;

H_0 : unit root : against

H_1 : stationary about determinstic trend

The PP test involves estimating the model;

$$R_t = \beta + \rho r_{t-1} + u_t \quad (3.20)$$

When we exclude the constant β and include a time trend t, the model is given as;

$$R_t = \alpha t + \rho r_{t-1} + u_t \quad (3.21)$$

The PP test consists of two (2) statistics known as Phillips Z_ρ and Z_τ tests given as;

$$Z_\rho = n(\hat{\rho}_n - 1) - {}^1/_2 \frac{n^2\hat{\sigma}^2}{s_n^2}\left(\hat{\lambda}_n^2 - \hat{\gamma}_{0,n}\right) \quad (3.22)$$

$$Z_\tau = \sqrt{\frac{\hat{\gamma}_{0,n}}{\hat{\lambda}_n^2}} \times \frac{\hat{\rho}_n - 1}{\hat{\sigma}} - {}^1/_2 \left(\hat{\lambda}_n^2 - \hat{\gamma}_{0,n}\right) \frac{1}{\hat{\lambda}_n} \frac{n\hat{\sigma}}{s_n} \quad (3.23)$$

$\hat{\gamma}_{j,n} = {}^1/_n \sum_{i=j+1}^{n} \hat{u}_i \hat{u}_{i-j}$, when $j=0$, then $\hat{\gamma}_{j,n}$ is a maximum likelihood estimate of the variance of the error terms, whiles for $j > 0$, $\hat{\gamma}_{j,n}$ is an estimate of the covariance between two error terms j periods apart.

$\hat{\lambda}_n^2 = \hat{\gamma}_{0,n} + 2\sum_{j=1}^{q}(1 - \frac{j}{q+1})\hat{\gamma}_{j,n}$, if there is no autocorrelation between the error terms, $\hat{\gamma}_{j,n} = 0$ for $j > 0$, then $\hat{\lambda}_n^2 = \hat{\gamma}_{0,n}$. Replacing, $\hat{\lambda}_n^2$ *as* $\hat{\gamma}_{0,n}$ in Z_τ, it reduces to;

$Z_\tau = \frac{\hat{\rho}_n - 1}{\hat{\sigma}}$, which is a *t*-statistic in the standard Dickey-Fuller (DF) equation. Hence if there is no autocorrelation between the error terms, the PP test is equal to the DF statistic with constant and time trend.

Also, when the covariance are equal, then $\hat{\lambda}_n^2 = \hat{\gamma}_{0,n}$, the error terms have the constant variance property (Homoscedastic), therefore $Z_\rho = n(\hat{\rho}_n - 1)$ is the same as the DF test.

$s_n^2 = \frac{1}{n-k}\sum_{i=1}^{n}\hat{u}_i^2$ is an ordinary least square (OLS) unbiased estimator of the variance of the residual error terms, where u_i is the OLS residual, k is the number of covariates in the regression, q is the number of Newey-West lags to use in the calculation of $\hat{\lambda}_n^2$and $\hat{\sigma}$ is the OLS standard error of $\hat{\rho}$.

3.3.1c Zivot-Andrews (ZA) Unit Root Test

The ADF and PP test discussed above have the weakness of not detecting the presence of structural breaks in the time series. Structural breaks are common signs in many economic times series variables. If structural changes are not allowed for in the specification of an economic model, but are, infact present, the results may be bias towards the erroneous non-rejection of the non-stationarity hypothesis (Perron, 1989; Perron, 1997; Leybourne and Newbold, 2004). Zivot and Andrews (1992) initiated a test procedure of unit roots that detects a single-term structural break point endogenously in the data such that, the bias in the usual unit root test such as ADF and PP test can be reduced. This study used the proposed ZA test to check whether or not the rates studied were covariance stationary in the presence of any structural changes. The ZA statistics test the hypothesis;

H_0 : unit root with structural break

H_1 : broken trend stationary process

The model endogenises one structural break in the series;

$$R_t = \mu + \gamma r_{t-1} + \mu_t \quad (3.24)$$

as follows;

$$R_t = \hat{\mu} + \hat{\theta} Du_t(\hat{T}_b) + \hat{\beta}_t + \hat{\gamma} DT_t(\hat{T}_b) + \hat{\gamma} r_{t-1} + \sum_{j-1}^{k} \hat{c}_j \Delta r_{t-j} + \hat{u}_t \quad (3.25)$$

Equation (3.25) is referred to as model C by ZA and has room for the likelihood of a change in the intercept as well as a trend break. T_b is the time of break, Du_t is a sustained dummy variable capturing a shift in the intercept and DT_t represents another dummy variable representing a break in the trend occurring at time T_b.

where $\begin{cases} Du_t = 1, \text{if } t > T_b \\ 0 \quad \text{otherwords} \end{cases}$ and $\begin{cases} DT_t = t - T_b, \text{if } t > T_b \\ 0 \quad \text{otherwords} \end{cases}$, .

H_0 is rejected if the γ is statistically significant. The optimal lag is determined by the AIC, SBIC or t-test. T_b is chosen to minimized the one-sided t-statistic of $\gamma = 0$ in equation (3.24) and (3.25).Thus a break point is selected where the t-statistic from the ADF test of unit roots is minimal.

3.4. Co-integration Test

After investigating the unit roots and the possible integration of the variables, next up is examining whether there exist a long-run association between the variables. Hence, the cointegration test is performed. This study employs the Autoregressive Distributed Lag (ARDL) model approach developed by Pesaran and Shin (1999) and introduced in Pesaran *et al*. (2001).Traditionally, the cointegration approach provided by Johansen (1992) and Johansen-Juselius (1990) have widely been used to establish long–run relationship among certain variables. Their method of cointegration requires that variables be integrated of the same order. If the order of integration among variables is not the same, then long–run relationship among them cannot be established. The order of integration, with these traditional approaches, is established by using unit root tests which might suffer from low powers failing to reject the null hypothesis of non-stationarity (Alimi *et al*., 2015). Moreover, the results of these tests largely depend on the choice of optimal lag length, which cannot be conclusively determined.

The ARDL model of cointegration overcomes this problem by introducing bounds testing procedure to establish long run relationship among variables. It does not require, as such, that variables of interest have the same order of integration to model long run relationship. ARDL bounds testing approach has some advantages over the other cointegration techniques, such as: Engle and Granger (1987), Johansen (1992), Johansen-Juselius (1990), Gregory and Hansen (1996), Saikkonen and Lutkepohl (2000). For instance, this approach can be applicable if running variables have ambiguous order of integration i.e. purely I(0), purely I(1) or I(0) / I(1) which is not acceptable in traditional approaches. In order words, it has three advantages which differentiate it from other previous and traditional cointegration methods. The first one is that the ARDL does not need that all the variables under study must be integrated of the same order and it can be applied when the under-lying variables are integrated of order one, order zero or fractionally integrated. Secondly the ARDL test is relatively more efficient in the case of small and finite sample data sizes (Haug, 2002; Halicioglu, 2007). The third advantage is that by applying the ARDL technique we obtain unbiased estimates of the long-run model (Harris and Sollis, 2003). However, it requires that none of the explanatory variables is I(2) or higher so as to avoid spurious results. The ARDL bounds testing approach is more suitable and provides better results than multivariate cointegration approaches in case of small sample properties (Haug, 2002; Halicioglu, 2007). For details on econometric advantages of bounds testing in comparison to other single cointegration procedures, see Bahmani-Oskooee and Tankui (2008).

Following Alimi *et al*. (2015), the ARDL representation of the macroeconomic relationship between the selected variables can be constructed as:

$$TFPG = f(LPCI, LINF, LSSE, \ln\_trade, l\_excRate, LGCE, \ln\_RFL)$$

Where $TFPG$ is the dependent variable, with LPCI, LINF, LSSE, ln_trade, l_excRate, LGCE and RFL as the long run regressors. Accordingly, the ARDL Bounds test uses the F-statistics to test the joint null hypothesis of no cointegration, (H0: γ1 = 0), against the alternative hypothesis of cointegration, (H1: γ1 ≠ 0). The hypothesis in this study is expressed as follows:

$$H_0^F: (\alpha = 0) \cap \left(\sum_{j=0}^{q} \beta_j = 0\right)$$

Versus the alternative hypothesis

$$H_1^F: (\alpha \neq 0) \cup \left(\sum_{j=0}^{q} \beta_j \neq 0\right).$$

$if\ H_0^F$ is rejected, use the t-statistics to test the single hypothesis

$$H_0^t: \alpha = 0\ versus\ H_1^t: \alpha \neq 0$$

If H_1^F is rejected, use conventional z-tests (or Wald tests) to test whether the elements of θ are individually (or jointly) statistically significantly different from zero.

The **Decision criteria for the Bounds Test** is such that: If the calculated F-statistic is greater than the critical value of the upper bound $I(1)$, then we can conclude that there is cointegration. That is there is a long-run relationship. Reject the null hypothesis and estimate the long run model. On the other hand, if the F-value is lower than the critical value for the lower Bound $I(0)$, then we conclude that there is no cointegration, hence no long-run relationship exist between/among the variables. Do not reject the null hypothesis and proceed to estimate a short-run model. However if the F-value falls between the lower bound $I(0)$ and upper bound $I(1)$ then the test is considered inconclusive.

3.5 Dynamic Ordinary Least Square (DOLS) Model

The Stock and Watson's (1993) DOLS model is employed to estimate the long-run association between TFPG and the independent variables. Based on the existence of cointegration relationship for the TFPG model, a long-run relationship is estimated between the dependent and independent variables using the Stock and Watson's

(1993) dynamic ordinary least squares (DOLS) model. The presence of leads and lags for different variables in the model eliminates the bias of simultaneity within a sample and DOLS estimates provide better approach to normal distribution (Hussein, 2007).

Stock-Watson (1993) Dynamic OLS model with dependent variable y_t and independent variable X_t is specified as below:

$$y_t = \phi_0 + \phi_1 X_t + \sum_{j=-m}^{n} d\Delta X_{t-j} + \varepsilon_t \qquad (3.26)$$

Where n and m show lag and lead length, and ϕ, (cointegrating vector) indicates the long run effect of a change in x on y. The reason why lag and lead terms are included in DOLS model is that they have the role to make its stochastic error term independent of all past innovations in stochastic regressors (Gutierrez, 2010; and Baba *et al*, 2013). The DOLS estimator corrects standard OLS for bias induced by endogeneity and serial correlation. The DOLS estimator is preferred to the non-parametric Fully Modified Ordinary Least Squares (FMOLS) estimator because of its better performance. According to Wagner and Hlouskova (2010), the DOLS estimator outperforms all other studied estimators, both single equation estimators and system estimators, even for large samples. More so, Harris and Sollis (2003) suggest that non-parametric approaches such as FMOLS are less robust if the data have significant outliers and also have problems in cases where the residuals have large negative moving average components, which is a fairly common occurrence in macroeconomic time series data.

3.6 Diagnostic Test

The DOLS model is diagnosed using: Breausch-Godfrey serial correlation LM test; Ramsey test for functional form misspecification; Jarque-Bera test of normality of residual; and Breusch-Pagan / Cock-Weisberg test for heteroscedasticity.

CHAPTER FOUR

ANALYSIS AND DISCUSSION

4.0 Introduction

This chapter presents, analyses, interprets and discusses the results of the study. Specifically, it consists of the descriptive statistics of the variables, the estimation results and discussions.

4.1 Descriptive statistics of the variables

This section presents and explains the descriptive statistics of the main variables used in the estimation, namely, TFPG, Per Capita Income, Inflation, education, trade openness, exchange rate, government expenditure and rainfall variables. From Table 4.1 and 4.2, apart from the estimated variable TFPG, it is evident that, over the study period, the real exchange rare has a larger variability than the other study variables as measured by their coefficient of variations (CV).

Generally, the trade variable (trade), output, land and agricultural labour have negative excess kurtosis of -0.75, -0.24, -0.99 and -0.99 respectively, for the study period, which indicates that these series were platykurtic in nature. The other variables: farm machinery; animal feed; fertilizer consumption; livestock; TFPG, PCI, inflation rate; SSE; exchange rate; GCE and Rainfall however have positive excess kurtosis indicating a leptokurtic series. All the study variables, with the exception of farm machinery (K) and TFPG for the study period are positively skewed. The Jaque-Bera test for normality revealed that N, GCE and trade openness are normally distributed. The rest of the other study variables are, however, not normally distributed, since the obtained test statistic was significant at the 5% level of significance.

Table 4. 1: Descriptive Statistics of Inputs

Statistics	Variable						
	Y	**L**	**K**	**N**	**Feed**	**Fertilizer**	**Livestock**
Mean	3239610	4471.7	2203.1	3651.53	873771	26124.5	2074.39
Std Dev.	1937830	1388.8	193.8	1446.06	812136	33247.4	761.447
CV	0.598	0.311	0.088	0.396	0.929	1.273	0.367
Minimum	1470610	2955.73	1169.4	1849.68	119306	1849.68	853.237
Maximum	7926180	6991.82	2522.46	6637	2934460	163361	4079.46
Skewness	1.014	0.779	-3.128	0.513	1.117	2.144	0.828
Ex. Kurtosis	-0.238	-0.993	14.014	-0.991	0.059	4.685	0.096
Jarque-Bera test	9.38096	7.678	529.978	4.575	11.239	90.754	6.192
Probability	0.009	0.02152	0.000	0.102	0.0036	0.000	0.045
Number of data points	54	54	54	54	54	54	54

Source: Author's construct, 2019.

Table 4. 2: Descriptive Statistics of TFPG and Determinants

Statistics	Variable							
	TFPG	**PCI**	**INF**	**SSE**	**Trade**	**ExcRate**	**GCE**	**RFL**
Mean	0.97	757.46	27.20	923827	54.226	0.370	1E+09	125.51
Std Dev.	0.17	157.52	22.33	500007	27.653	0.633	2.44E-09	21.82
CV	6.56	0.21	0.82	0.54123	0.510	1.712	2.439	0.17
Minimum	0.47	525.49	1.94	503784	6.320	7.14E-05	10100	77.60
Maximum	1.42	1243.27	123.06	2295190	116.048	2.900	1.06E+10	184.80
Skewness	-0.75	1.36	2.08	2.859	0.381	1.984	2.859	0.23
Ex. Kurtosis	1.64	2.02	5.36	0.961	-0.744	3.786	0.005	0.005
Jarque-Bera test	10.96	25.76	103.53	19.5671	2.553	67.668	4.657	2635.59
Probability	0.00	0.000	0.000	0.000	0.279	0.000	0.097	0.000
Number of data points	53	54	54	54	54	54	54	54

The time series plots in the Figures below reveal that TFPG and its determinants fluctuated with time.

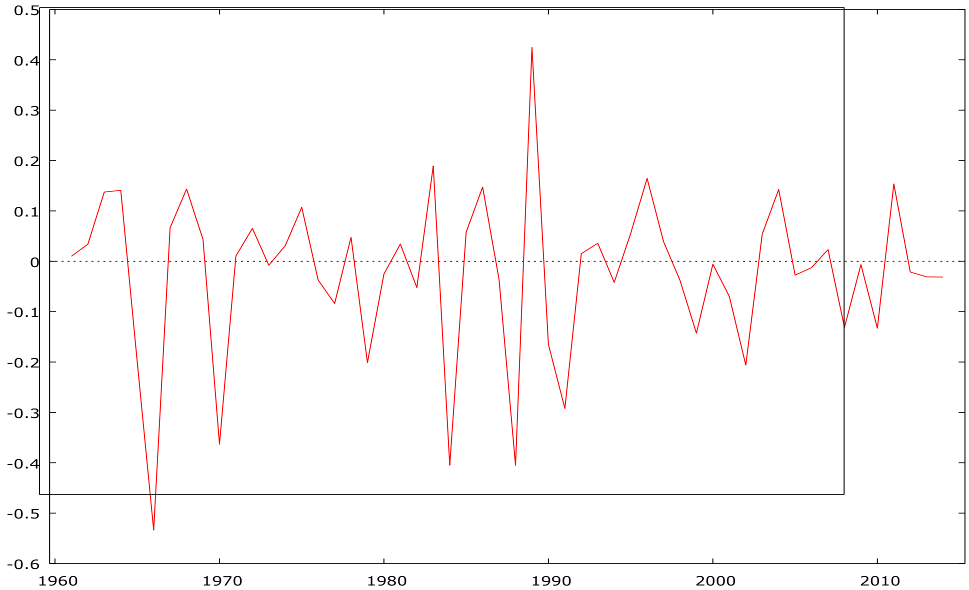

Figure 4a: TFPG

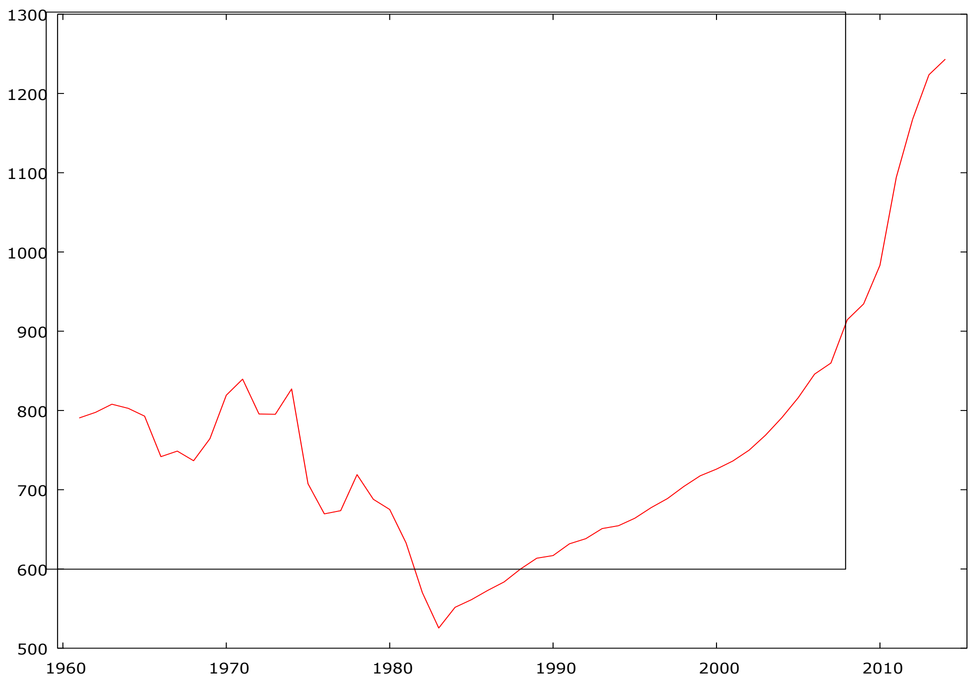

Figure 4b: Per Capita Income

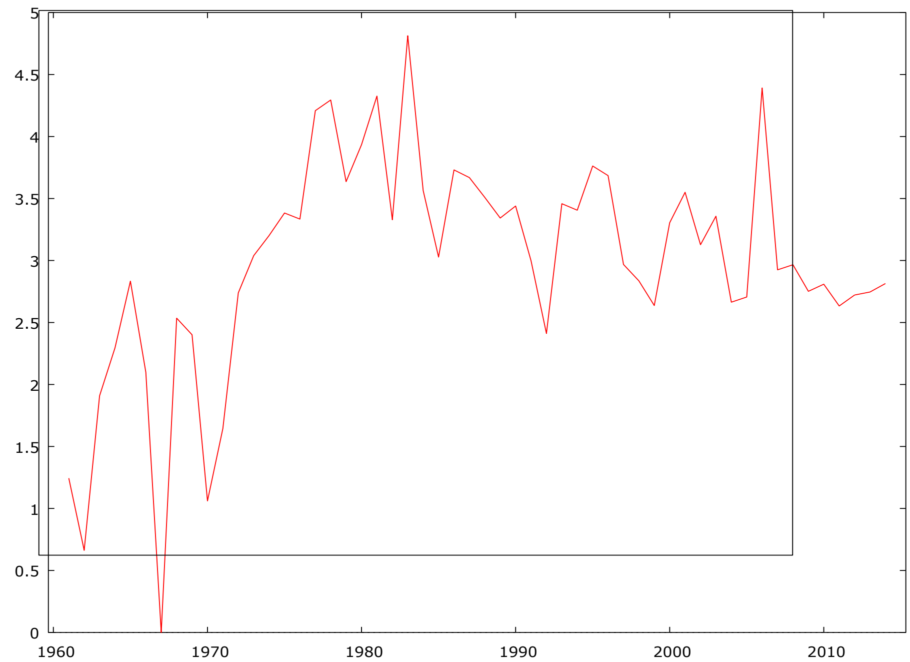

Figure 4c: Inflation

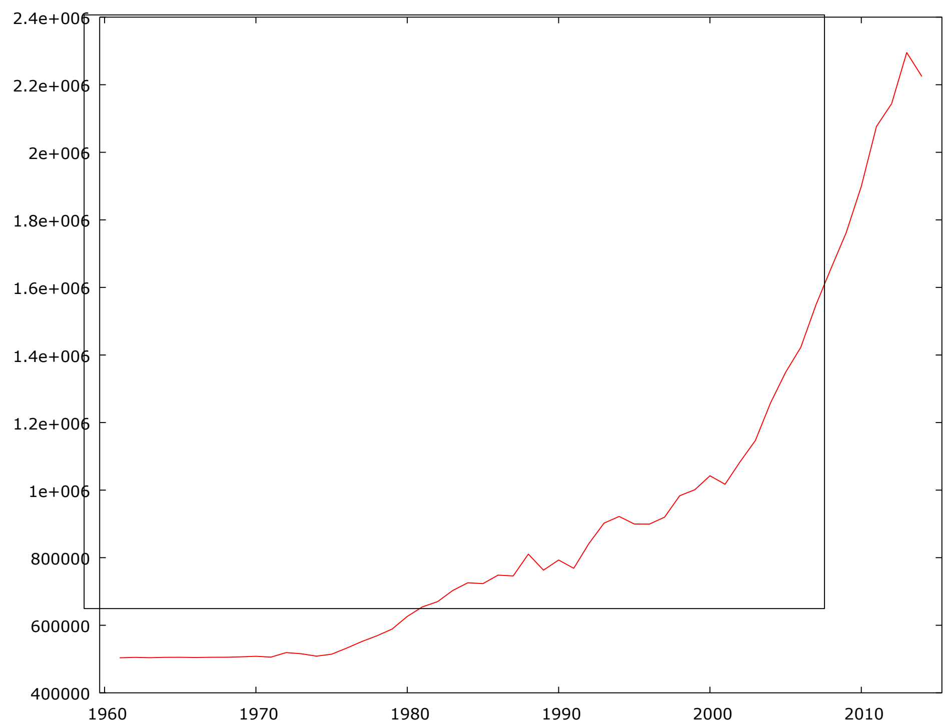

Figure 4d: SSE (Education)

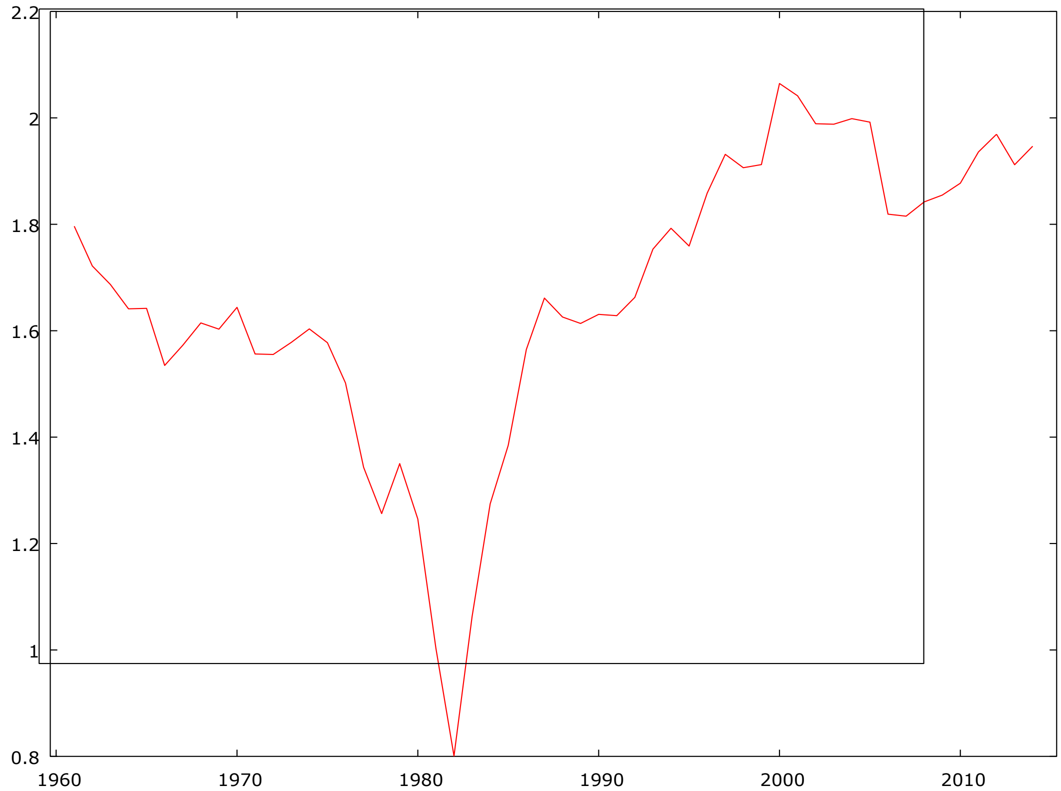

Figure 4e: Trade openness

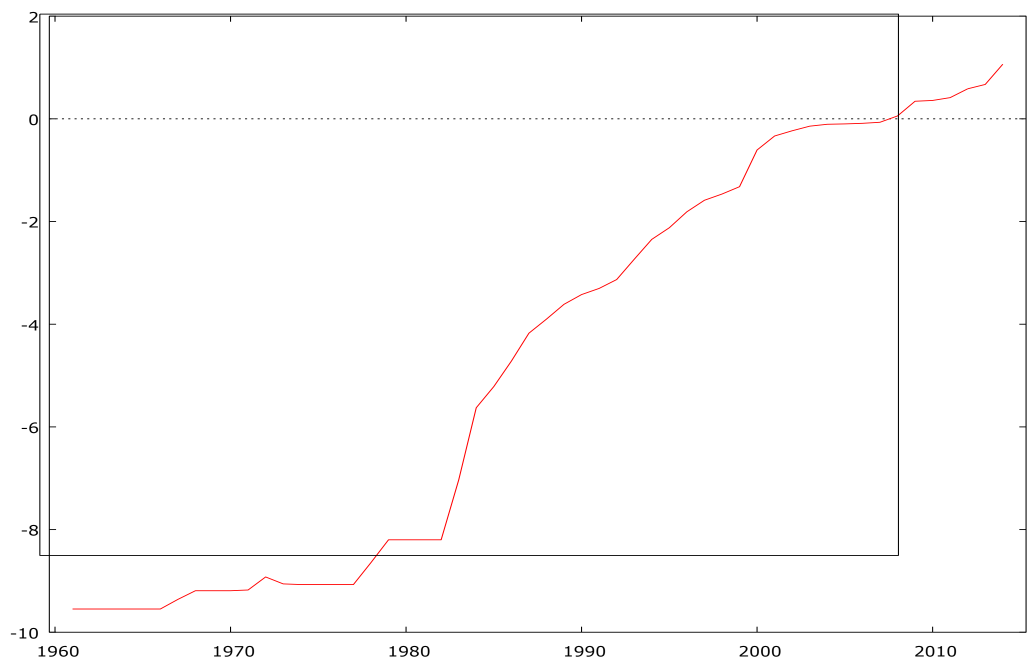

Figure 4f: Exchange Rate

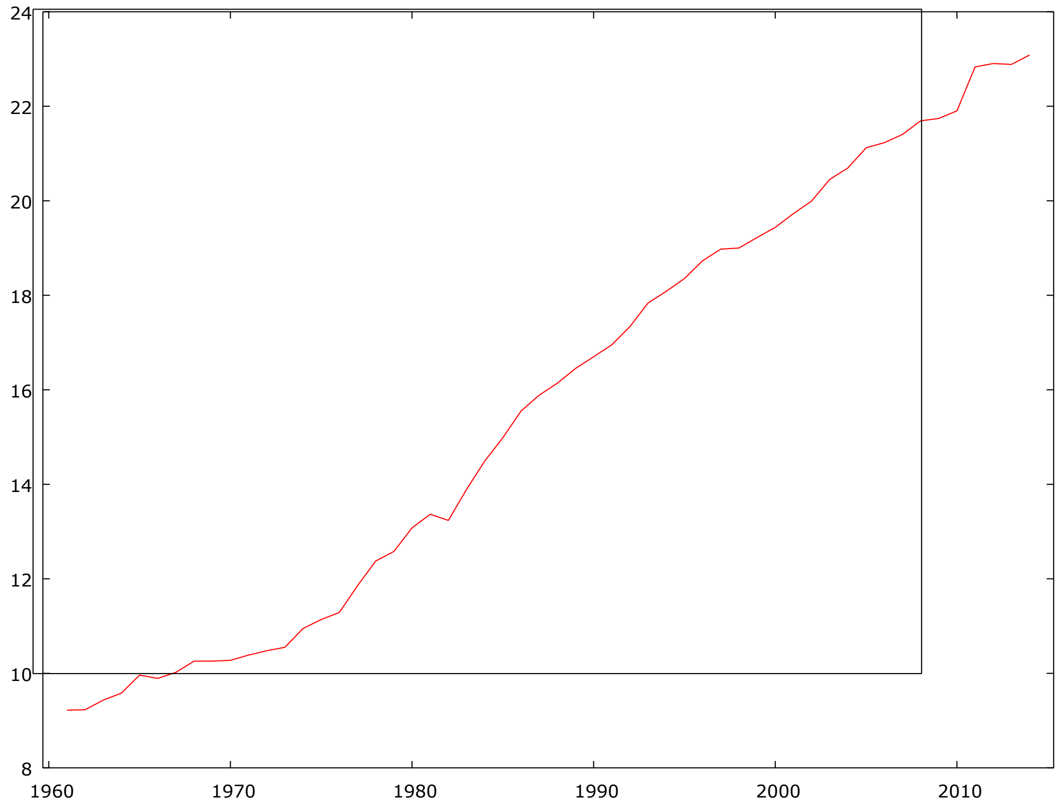

Figure 4g: GCE

Figure 4h: Rainfall

4.2 Total Factor Productivity

The input shares of agricultural output as in equation 3.2, was estimated with a CRS constraint as follows:

$$\ln y = 12.53 + 0.49lnL - 0.02lnK - 0.63lnN - 0.01lnFert + 0.75lnLivst + 0.42lnFeed \quad (4.1)$$

Table 4. 3: Estimating Input-Shares of Agricultural output

Input	Coefficients	Standard errors	P-value
Constant	12.53	0.569	0.000
Agricultural Land	0.49	0.121	0.000
Farm Machinery	-0.02	0.015	0.932
Agricultural Labour	-0.63	0.1832	0.001
Fertilizer Consumption	-0.01	0.025	0.824
Livestock	0.75	0.335	0.031
Animal Feed	0.42	0.096	0.000
F(6, 48) R^2 = 0.956, Adjusted R^2 = 0.952 Std. Error = 0.120			

Source: Author's construct, 2019.

The data was again transformed from its levels to growth rates to suit equation 3.5. The growth rate of agricultural output was then regressed on the growth rate of the other six inputs. The variable of focus in this estimation is the total factor productivity growth rate(G_A).

$$G_Y = -0.07 + 0.66G_L + 0.02G_K + 2.94G_N - 0.02G_{Fert} + 0.65G_{Livst} + 0.10G_{Feed} \quad (4.2)$$

The intercept,(G_A), which represent the growth rate of TFP per annum is - 0.07%. When multiplied by 53, the total factor productivity growth for the entire period becomes -3.71%. In terms of techniques and period of study, these results can be compared to Fugile (2015) who found an annual growth - 0.061% for Ghana in his "Accounting for Growth in Global Agriculture". The growth rate of farm machinery was however not significant at 5% level of significance.

Table 4. 4: Estimation Results of TFPG

Year	TFPG	Year	TFPG	Year	TFPG	Year	TFPG
1962	0.034	1976	-0.037	1990	-0.165	2004	0.143
1963	0.137	1977	-0.084	1991	-0.292	2005	-0.028
1964	0.141	1978	0.048	1992	0.015	2006	-0.013
1965	-0.199	1979	-0.201	1993	0.036	2007	0.023
1966	-0.534	1980	-0.025	1994	-0.042	2008	-0.131
1967	0.067	1981	0.034	1995	0.055	2009	-0.006
1968	0.143	1982	-0.052	1996	0.165	2010	-0.133
1969	0.043	1983	0.189	1997	0.039	2011	0.154
1970	-0.363	1984	-0.405	1998	-0.038	2012	-0.021
1971	0.010	1985	0.058	1999	-0.143	2013	-0.031
1972	0.065	1986	0.147	2000	-0.006	2014	-0.031
1973	-0.008	1987	-0.036	2001	-0.070		
1974	0.031	1988	-0.405	2002	-0.206		
1975	0.107	1989	0.425	2003	0.054		

Source: Author's Construct, 2019.

The results of TFPG displayed above indicate that TFPG experienced fluctuations over the entire 53 year period. From 1962 to 2014, the highest negative growth and positive growth respectively occurred in 1966 and 1989. The highest inverse growth in TFP could be due to the 1966 uprisings and the best of the positive growths could be associated to the returns/gains from the Economic Recovery Programme (ERP) and Structural Adjustment Programme (SAP) in the 80s.

4.3 Trend Analysis

The nature of trend characterising the TFPG and its determinants over time were investigated by assessing the Linear, Quadratic, Log-linear and Log-quadratic time trend models. The results, as shown in Table 4.5, indicates that, the TFPG and Rainfall were best modelled by a log-linear time trend; since this trend model specification had the least AIC, SBIC and HQIC values as well as the maximum adjusted *R*-squared value. The adjusted *R*-squared values for the TFPG and Rainfall models were about -1.4% and 4% respectively. The PCI, INF, SSE, Trade, and GCE were best modelled by log-quadratic time trend. The adjusted *R*-squared values for the best models were about 82.8%, 48.5%, 98.4%, 46.3%, and 99.4% for PCI, INF, SSE, trade and GCE respectively. The exchange rate was however best modelled by a quadratic time trend with an adjusted R-squared of 94.2%. From the above, it suffices to conclude that the trend models fitted accounts for a larger portion of the variation in the variables, hence the models are good.

Table 4. 5: Trend Analysis of TFPG and Determinants

Variables	Model	R^2 Adjusted	AIC	SBIC	HQIC
TFPG	Linear	0.02	-36.97	-33.03	-35.45
	Quadratic	0.04	-34.98	-29.07	-32.71
	Log-Linear*	-0.01*	-109.34*	-105.40*	-107.82*
	Log-Quadratic	-0.03	-107.36	-101.45	-105.09
PCI	Linear	0.15	692.94	696.92	694.48
	Quadratic	0.83	606.44	612.40	608.74
	Log-Linear	0.11	-29.72	-25.75	-28.19
	Log-Quadratic	0.83*	-117.47*	-111.50*	-115.17*
INF	Linear	-0.01	491.34	495.31	492.87
	Quadratic	0.23	477.81	483.78	480.11
	Log-Linear	0.08	130.78	134.76	133.31
	Log-Quadratic	0.49*	100.58*	106.55*	102.88*
SSE	Linear	0.78	1491.71	1495.69	1493.25
	Quadratic	0.95	1407.83	1413.79	1410.13
	Log-Linear	0.92	-60.76	-56.78	-59.23
	Log-Quadratic	0.98*	-151.40*	-145.44*	-149.10*
Trade	Linear	0.46	480.37	484.35	481.91
	Quadratic	0.59	466.90	472.87	469.21
	Log-Linear	0.30	-4.55	-0.57	-3.01
	Log-Quadratic	0.46*	-18.06*	-12.09*	-15.76*
excRate	Linear	0.59	57.53	61.51	59.07
	Quadratic	0.94*	-18.72*	-12.76*	-16.42*
	Log-Linear	0.94	59.59	63.57	61.12
	Log-Quadratic	0.94	60.46	66.43	62.76
GCE	Linear	0.36	2465.50	2469.50	2467.01
	Quadratic	0.70	2426.40	2432.30	2428.70
	Log-Linear	0.99	86.39	90.37	97.92
	Log-Quadratic	0.99*	84.13*	90.10*	86.43*
RFL	Linear	0.02	486.94	490.93	488.48
	Quadratic	0.03	487.08	493.04	489.38
	Log-Linear	0.04*	-33.06*	-29.08*	-31.52*
	Log-Quadratic	0.03	-32.72	-26.76	-30.42

*Denotes the best model selected by information criteria
Source: Authors Construct, 2019.

The parameters of the best trend model for each of the variables were estimated as shown in Table 4.6. It is seen that, with the exception of the time trend of TFPG and SSE and the time-squared trend of the exchange rate, the parameters of the individual trend models were significant at the 5% significance level; thus these time parameters significantly account for variation in most of the dependent variables considered.

Table 4. 6: Estimated Parameters of the Best Trend Models for the Determinants

Variable	Model	Coefficient	Std Error	t-ratio	p-value
ln_TFPG	Constant	-0.030	0.046	-0.696	0.489
	Time (t)	0.000	0.001	0.181	0.867
LPCI	Constant	6.867	0.034	204.119	0.000
	Time (t)	-0.036	0.003	-12.749	0.000
	Time squared (t^2)	0.001	0.000	14.756	0.000
LINF	Constant	1.302	0.253	5.140	0.000
	Time (t)	0.149	0.021	7.041	0.000
	Time squared (t^2)	-0.002	0.000	-6.449	0.000
LSSE	Constant	13.126	0.025	534.182	0.000
	Time (t)	-0.002	0.002	-1.047	0.300
	Time squared (t^2)	0.001	0.000	15.249	0.000
ln_Trade	Constant	1.664	0.084	19.697	0.000
	Time (t)	-0.019	0.007	-2.632	0.011
	Time squared (t^2)	0.001	0.000	4.12	0.000
excRate	Constant	-4.854	0.175	-27.778	0.000
	Time (t)	0.092	0.015	6.292	0.000
	Time squared (t^2)	0.000	0.000	1.039	0.304
LGCE	Constant	8.053	0.218	37.014	0.000
	Time (t)	0.255	0.018	13.977	0.000
	Time squared (t^2)	0.000	0.000	2.045	0.046
Ln_RFL	Constant	4.878	0.048	101.010	0.000
	Time (t)	-0.002	0.002	-1.423	0.158

Source: Author’s construct, 2019.

Thus, the estimated trend models of the variables are given as;

Per Capita Income; $LPCI = 6.867 - 0.036t + 0.001t^2$ (4.3)

Inflation; $LINF = 1.302 + 0.149t - 0.002t^2$ (4.4)

Education; $LSSE = 13.126 + 0.001t^2$ (4.5)

Trade Openness; $\ln\_Trade = 1.664 - 0.019t - 0.0005t^2$ (4.6)

Exchange Rate; $excRate = -4.854 + 0.092t$ (4.7)

Infrastructure; $LGCE = 8.0526 + 0.255t + 0.0007t^2$ (4.8)

4.4 Further Analysis

The further analysis involved investigating the dynamic interrelationship between the variables under study measured over time. This relationship was investigated by accessing the stationarity of the variables, undertaking cointegration test and fitting a long-run equilibrium model.

4.4.1 Unit Root Test on Levels of the Series

The levels of the data were tested for stationarity to establish the integration order of the study variables measured over time. The time series plot of the undifferenced series of TFPG and its determinants as in Figure 4.1 showed that, apart from TFPG and Rainfall, the series do not fluctuate around a constant mean, thus, giving an indication of non-stationary in the levels of the other series.

To confirm the stationarity and non-stationarity of the levels of the determinants, a stationarity test was conducted. The null hypothesis of the unit root were tested against the alternative hypothesis of stationarity by the Augmented Dickey-fuller (ADF) test, including an intercept but not a trend and with an intercept and a linear trend. As shown in Table 4.7, a significant ADF was obtained for TFPG and Rainfall at the 5% level of significance. Thus the null hypothesis of the presence of unit root was rejected for these variables and concluded that the above mentioned series were stationary at levels. Hence TFPG and Rainfall are integrated of order zero denoted by *I* (0).On the other hand, an insignificant Augmented Dickey-fuller (ADF) test statistic was obtained for PCI, INF, SSE, Trade, excRate and GCE at the 5% significance level when either a constant or constant with time trend were modelled in the test. This therefore leads a failure to reject the null hypothesis of unit root, hence affirming the existence of unit roots in the levels of those variables.

Table 4. 7: Unit Root Test at Levels

Variables	ADF		PP	
	Intercept	Intercept and Trend	Intercept	P-value
ln_TFPG	-4.689***	-4.714***	-11.747	0.000
LPCI	-0.169	1.408	1.611	0.999
LINF	-2.259	-2.155	-5.192	0.000
LSSE	0.869	-1.551	5.135	1.000
ln_trade	-1.576	-2.395	-1.293	0.627
l_excRate	-0.135	-2.160	0.106	0.963
LGCE	0.746	-2.410	5.3153	1.000
LRFL	10.383***	-10.958***	-10.115	0.000

*** Means significant at 1% significance level

Source: Author’s construct, 2019.

The PP test also confirmed the presence of unit roots in the levels of TFPG and Rainfall. The results of the PP test as shown in Table 4.7 confirms the ADF test result at the 5% level of significance with the only exception being that inflation is reported to be stationary at levels. These results further indicate that the rates are individually not covariance stationary. Alimi *et al*. (2015) had similar findings at levels.

The Zivot-Andrews (ZA) test, which test for unit roots in the presence of structural breaks in a given series, was performed. The structural breakpoint for all the time-series is 1983 corresponding to the inception of the ERP/SAP. As shown in Table 4.8, a significant ZA test was obtained for TFPG and Rainfall at the 5% level of significance demonstrating the stationarity of those series at levels. Conversely, an insignificant ZA test was also obtained for PCI, INF, SSE, Trade, excRate and GCE at the 5% significance level, thus further confirming the non-stationary nature of those series. This indicates that the variables are without a time-invariant mean, variance and covariance structure.

Table 4. 8: ZA Test of the undifferenced series

Variable	Break point	Test statistic	Critical value	Decision on Ho of non-stationarity
ln_TFPG	1983	-8.018	-4.8	Reject
LPCI	1983	-1.475	-4.8	Fail to reject
LINF	1983	-4.751	-4.8	Fail to reject
LSSE	1983	-4.217	-4.8	Fail to reject
ln_trade	1983	-3.272	-4.8	Fail to reject
l_excRate	1983	-4.332	-4.8	Fail to reject
GCE	1983	-4.027	-4.8	Fail to reject
LRFL	1983	-8.724	-4.8	Reject

Source: Author's construct, 2019.

The variables with unit roots at levels were first differenced and again subjected to unit root testing. In other words, the variables were first differenced and tested for stationarity using the ADF, PP and ZA tests. All the tests as shown in Table 4.9 and 4.10 revealed that, after first differencing, the series were stationary at the 5% level of significance. This gives an indication that the other series are integrated of order one *I (1)*.This is in consonance with findings of Ali *et al*. (2014), Suphannachart and Warr (2010), among others.

Table 4. 9: Unit Root Test at First Difference

Variables	ADF		PP	
	Intercept	Intercept and Trend	Intercept	P-value
ln_TFPG	-4.689**	-4.714**	-8.267	0.000
LPCI	-0.169**	1.408**	-4.410	0.001
LINF	-2.259**	-2.155**	-17.098	0.000
LSSE	0.869**	-1.551**	-4.076	0.002
ln_trade	-5.246**	-5.297**	-4.942	0.000
l_excRate	-4.063**	-4.045**	-3.936	0.003
LGCE	-7.696**	-6.44**	-10.173	0.000
LRFL	-5.531**	-5.601**	25.735	0.000

**Means significant at 5% significance level

Source: Author's construct, 2019.

Table 4. 10: ZA Test of the Differenced series

Variable	**Break point**	**Test statistic**	**Critical value**	**Decision on Ho of non-stationarity**
ln_TFPG	1983	-9.277	-4.8	**Reject**
LPCI	1983	-6.582	-4.8	**Reject**
LINF	1983	-9.438	-4.8	**Reject**
LSSE	1983	-4.297	-4.8	**Reject**
ln_trade	1983	-8.128	-4.8	**Reject**
l_excRate	1983	-6.113	-4.8	**Reject**
GCE	1983	-5.052	-4.8	**Reject**
LRFL	1983	-7.165	-4.8	**Reject**

Source: Author's construct, 2019.

4.5 Co-integration Test and Fitting of DOLS Model

The unit root results reported in the section above show that TFPG and Rainfall are *I(0)* series. The other series contain unit root at levels though they become stationary after first differencing indicating *I(1)* series. The existence or presence of a long run relationship is the then tested using the Bounds approach to cointegration testing since the variables are integrated of different orders. A lag order of one was selected based on the minimum value of SBIC. An appropriate lag order aids avoid spurious results from the ARDL bounds cointegration test.

Table 4. 11: Lag Length Selection

Lag	LR	FPE	AIC	SBIC	HQIC
0	NA	2.50E-10	0.597	0.906	0.714
1	777.5*	4.50E-16*	-12.658	-9.878*	-11.603*
2	108.1	8.40E-16	-12.252	-7.001	-10.259
3	165.99	7.10E-16	-13.027	-5.305	-10.098
4	218.74	4.70E-16	-14.879*	-4.686	-11.012

Source: Author's construct, 2019.

ARDL Bounds cointegration test reported in Table 4.12 shows that when TFPG is the regressand, the F-statistic is found to be higher at 99% significance level than the upper critical bound values. This gives a clear indication that there is a long-run cointegration relation between per capita income, inflation, human capital, trade openness, exchange rate, government expenditure and rainfall when the TFPG variable is the dependent variable.

Table 4. 12: ARDL Bounds Test for Cointegration

Model Number	Variables	F – Statistics	Cointegration
1	(ln_TFPG/ LPCI, LINF, LSSE, ln_Trade, l_excRate, GCE, RFL)	9.834***	Yes
	Critical value	Lower Bound	Upper Bound
	1%	3.15	4.43
	5%	2.45	3.61
	10%	2.12	3.23

Notes: *** Statistical significance at 1% level.
The lag length k=1 was selected based on the Schwarz criterion (SC).
The number of regressors is 7.

Source: Author's construct, 2019.

4.6 Fitting of Dynamic Ordinary Least Square (DOLS) Model

Based on the existence of cointegration relationship for the TFPG model, a long-run relationship is estimated using the Stock-Watson's dynamic ordinary least squares (DOLS) model. The presence of leads and lags for different variables in the model eliminates the bias of simultaneity within a sample and DOLS estimates provide better approach to normal distribution.

The following inferences can be drawn from the DOLS model results reported in Table 4.13 which represents the nature of the long-run relationship with agricultural TFPG as the dependent variable. The results suggest that only one (PCI) out of the seven explanatory factors has a sign that is contrary to our *a priori* expectations. The results also indicated that the most significant factor influencing agricultural TFP in terms of elasticity was PCI.

Table 4.13: Stock-Watson's DOLS Long-Run Coefficients Estimates of TFPG

Variable	Coefficients	Standard errors	P-value
Constant	-1.524	0.3101	0.000
LPCI	-0.465	0.0458	0.000
LINF	-0.019	0.0055	0.001
LSSE	0.105	0.0369	0.004
ln_trade	0.232	0.0317	0.000
l_excRate	-0.145	0.0094	0.000
LGCE	0.122	0.0076	0.000
LRFL	0.093	0.0305	0.002
N = 50 R^2 = 0.677, Adjusted R^2 = 0.247 Std. Error = 0.074			

Source: Author's construct, 2019.

The results indicate that income per capita was negatively associated with the TFPG of agriculture. With a significant magnitude of -0.465, a one percent increase in per capita income decreases TFPG by 0.465 percent. Though highly significant, the sign of the coefficient was not in line with the researcher's *a priori* expectation. It could be an indication that high income earners either move out or shy away from agriculture in Ghana. This explains why majority of Ghanaian farmers are low income earners. The inverse relationship between these variables could also be a reflection of unequal income distribution in the country which is not in favour of the masses. Per capita income is normally used in studies of this kind to reflect the income level of the masses on agricultural productivity growth. However, given that per capita GDP is an overall indicator and not a direct measure of income per capita in the agricultural sector only, its effect on agricultural TFPG may not be favourable given the widened poverty in the sector relative to other sectors. In other words, widened income inequality as captured in the economic updates of Ghana (World Bank, 2018) implies that the income levels of the masses (mostly rural households) are very low. A very low income of the masses in the country may contribute towards decreasing TFPG and agricultural productivity through: 1) fall in demand which may result in reduction in production levels; 2) A low income of the farming folk affects their health and education level which, in turn, assumes to have negative impacts on productivity; and 3) Low income levels could also endanger access and improvement in new technology. Given the dominance of rural households in Ghana's agriculture (Xinshen Diao, 2010; World Bank, 2018)), a low standard of living of such households should be expected to have a dwindling effect on agricultural output. In a related study on Ghanaian agriculture, Enu and Attah-Obeng (2013) found GDP per capita to influence agricultural production negatively.

The results for inflation showed a significant adverse impact on TFPG of agriculture. With an elasticity of -0.019 a one percent increase in inflation decreases agricultural TFPG by 0.019 percent. Though with a small magnitude, the coefficient gave the direction between inflation and the TFPG of agriculture necessary for policy implications. The negative association linking this macroeconomic variable (inflation) and TFPG could be a signal that higher and unstable prices which tend towards inflation create a lot of uncertainties in the economy that does not encourage investment in agricultural related projects. The negative association revealed in this study could be due to the expectant effect of inflation in increasing capital flight and its inverse impact on investment, and hence TFPG as captured in several other empirical studies (Olopoenia 2000; Lensink *et al*. 1998; Dooley 1988). In addition, the inverse relation between inflation and TFPG may actually explain the observed negative relationship between inflation and growth documented in many empirical studies (Levine and Renelt 1992; Kormendi and Meguire 1985; Miller and Russek 1997). The result in this study is in consonance with the findings of Kogel (2005); Bernanke and Gurkaynak (2001); Miller and Upadhyay (2000); Fischer (1993); and Bregman and Marom (1993).

The estimated long-run coefficient of education is significant and positive signalling a direct association between TFPG and education. The results indicate that increasing secondary school enrolment by a percentage increases agricultural TFPG by 0.105 percent in the long run. This underscores the importance of education in improving the human capital endowment of the nation. In furtherance, education improves the capacity and capability of the labour force in production. The importance of education is beyond any doubt in uplifting the productive capacity of the farming community. The result of this variable also suggests that improvement in education contributes significantly to TFPG. It also demonstrates the importance of improving human capital endowment of the agricultural labour force to achieve increases in TFPG of agriculture. This is sync with the findings of Ali *et al.* (2012)

The results also explain that trade openness is positively and significantly related to agricultural total factor productivity growth with a magnitude of 0.23. This implies that a one percentage rise in agricultural trade increases agricultural total factor productivity growth by 0.23 percent. The sign of the coefficient is as expected because international trade, especially in agricultural commodities, is normally believed to have a complementary effect on agricultural TFPG. Openness of an economy to trade enlarges market size, guarantees healthy degree of free competition, promotes international mobility of factors of production, increases total world output of commodities, among others. All these play a significant role in achieving economies of scale. Economies of scale ensure reduction in production cost, thereby increasing production. Also it is documented in literature that liberalized economies develop faster through widened access to imported inputs and technologies that are significant to productivity growth (Ali *et. al.*, 2012). The finding in this study is in line with the findings of (Urata and Yokota, 1994; Edwards, 1998; Acemoglu and Zilbotti, 1999; Mayer, 2001; Rao *et al.*, 2004; Alauddin *et al.*, 2005; Wilson, 2006; Suphannachart and Warr, 2010; Ali *et al.*, 2012).

The study established that the Real Exchange rate impacts on agricultural TFPG negatively and significantly. The result indicates that TFPG of agriculture decreases by 0.145 with a one percent increase in the real exchange rate. The inverse association gives an indication that improvement in agricultural productivity is dampened by a fall in the exchange rate. This further gives an indication that a depreciating currency has a telling effect on productivity growth. There are two well-known hypotheses on the relationship between the exchange rate and productivity, (Lafrance and Schembri, 2000). The first is the "exchange-rate-sheltering" hypothesis which attributes a depreciating real exchange rate and decline in production and productivity to the fact that local producers are sheltered from competition thereby reducing their incentive to make investments that are productivity enhancing. This reduces their incentive to make productivity enhancing investment. The second hypothesis, the "factor-cost" hypotheses, stipulates that movements in the real exchange rate affect the absolute and relative cost of new capital and labour, therefore influencing both total factor productivity and labour productivity. Porter (1998), in his book on competition and growth, pointed out that currency depreciation can reduce growth, and an overvalued exchange rate can sometimes contribute to productivity growth by forcing productivity gains in the tradable sector. This finding implies that a higher exchange rate makes it expensive to import agricultural inputs such as fertilizer and technical know-how necessary for the transformation of the sector. Thus, maintaining a weak exchange rate will stifle agricultural TFPG. Diallo (2013) in a study notes that exchange rate volatility affects TFPG negatively. His study also found that Real Exchange rate (REER) volatility reacts negatively on productivity. The findings of this study, however, contradict Rodrik's (2010) argument of maintaining a weak real exchange rate.

The coefficient of General Government consumption expenditure (infrastructure development) is 0.122. This implies that a one percentage swell in government expenditure increases agricultural TFPG by 0.122 percent in the long-run. The significant and direct association between these variables justifies the need to improve investments in this sector on regular basis. When there is improvement in infrastructure through storage system and road network, it aids in reducing post-harvest losses which results in improved returns to farmers, hence making them more productive. Improved infrastructure through increased government expenditure will also help attract more domestic and foreign investments that would further increase productivity of Ghanaian agriculture. Rao *et al*. (2004) found government expenditure to impact positively and significantly on TFP of agriculture. In a related study, Zhang and Fan (2001) found that infrastructure development positively influence productivity in Indian agriculture. The findings of this study are in accordance with that of Ali *et al*. (2012).

The results also show that rainfall is a significant factor influencing TFPG of Ghanaian agriculture in the long run. Rainfall is established in the study to influence TFPG of agriculture positively and significantly. This suggests that climate is an essential factor causing variations in agricultural fortunes. The result shows the magnitude of the climate or weather variable in the study in relation to agricultural TFPG to be 0.093. This gives an indication that improved rainfall increases efficiency in agricultural land use and hence, agricultural productivity. The results denote that a one percent increase in the volumes of rainfall increases TFPG of agriculture by 0.09 percent in the long-run. The high significance of rainfall in the present study might be due to the high dependence of Ghanaian agriculture on rainfall. Rainfall is an important input in determining the aggregate agricultural output of any country. There is no dispute that agricultural performance in Ghana, and indeed in many other developing countries, relies heavily on climate. Output in the agricultural sector is to a large extent closely related to rainfall. Rainfall is such an important input that its quantity, pattern and timing can have a disastrous effect on agricultural output as a whole. It is worth stating that even irrigation-dependent production needs rainwater to reinforce the dams for efficient operation. The results of the study therefore suggest that good weather resulting in consistent rainfall or less occurrence of drought raises TFPG relative to the opposite. Craig *et al*. (1997), Wiebe *et al*. (2000, 2003), and Alauddin *et al*. (2005), discovered a positive relationship between rainfall and agricultural productivity. Excess rainfall (rainfall squared) is reported to impact negatively on the levels of agricultural TFP (Alaudin *et al*., 2005).

4.7 DIAGNOSTIC TEST

The Diagnostic Tests in this study consist of: Breausch-Godfrey serial correlation LM test; Ramsey test for functional form mis-specification; Jarque-Bera test of normality of residual; and Breusch-Pagan/Cook-Weisberg test for heteroscedasticity.

Table 4. 14: Diagnostic test results

Diagnostic Test	p-value
Serial Correlation, Chi2 = 2.522	0.112
Normality JB = 0.84	0.430
Heteroscedasticity chi2 = 0.975	0.324
Ramsey Test F(3, 41) = 1.04	0.383

Source: Author’s construct, 2019.

All the diagnostic tests, reported in table 4.14, provided satisfactory results. The Breusch-Godfrey LM-test indicated that there is no problem of serial correlation among the residuals. The Durbon-Watson statistics also showed no evidence of serial correlation among the residuals. The Ramsey RESET-test also verified the correct functional form of the model. The Jarque-Bera test gave conclusion about the normal distribution of the residuals. Similarly the R^2 value of 0.677 indicated that about 67.7 percent variation in the total factor productivity growth in agriculture was explained by the factors included in the model.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter presents the summary, conclusions and recommendations of the study.

5.1 Summary of findings

An important ingredient in accelerating the pace of economic growth is increases in agricultural productivity. With incessant increases in population and a diminishing supply of per capita arable land, there is increasing need for growth in food supply that could only emanate from growth in productivity rather than increases in the usage of inputs. There is, however a slow-down in Ghanaian agriculture despite the numerous studies that have been conducted on agricultural productivity in Ghana. Very few of those studies are focused on TFP measurements, trends and its determinants despite the immeasurable importance of TFPG in agricultural productivity growth.

The present study investigated agricultural TFP in Ghana to give improved empirical evidence on the measurement of total factor productivity, trends of TFPG and its determinants. It used annual time series data at the national level over the duration 1961-2014 for both crops and livestock, aggregated. The study employed the Solow index technique of the conventional growth accounting framework in measuring TFP of Ghanaian agriculture.

The study also fitted an appropriate time trend model to illustrate the existing association involving the variables and time. The exploration revealed that the TFPG and rainfall (RFL) have a log-linear growth model trend while per capita income (PCI), inflation (INF), human capital (SSE) and government consumption expenditure (GCE) have a quadratic constant growth. However, the exchange rate has a quadratic time trend.

The TFP measure in the study was used to examine the effect of several macroeconomic and climatic variables (Per Capita Income, Inflation, education trade openness, exchange rate, government expenditure and rainfall) on TFPG of Ghanaian agriculture by employing Stock-Watson's Dynamic Ordinary Least Squares (DOLS). The DOLS test results showed a -0.07%growth in the total factor productivity of Ghanaian agriculture grew at -3.78% over the entire study period with an annual growth rate of -0.07%. The results also indicated that human capital, infrastructural development, trade openness, and rainfall impacted positively and significantly on TFPG. Per capita income, inflation and the exchange rate had a negative and significant effect on TFPG. In effect, the results showed that policies which advance human capital development, ensure price stability, facilitate trade openness, improve infrastructural development, promote exchange rate stability and drought controlling factors; would result in a higher agricultural productivity growth in Ghana.

5.2 Recommendations

The following policy actions and recommendations are suggested to improve TFPG in Ghanaian agriculture based on the findings of the study.

Firstly, the government should institute and improve on existing measures of income redistribution such as fertilizer and improved seeds subsidization. In this regard, the PFJ, if well handled, would be a lever in improving the agricultural fortunes of rural farmers that translates into improved incomes. Administrative hurdles in any income redistribution process must be removed and stern attention must be exhibited to ensure that the target is reached. It is also recommended that any measure deemed significant by stakeholders in improving the financial standing of farmers must be advanced. It must be stated that the income redistribution measures should be in kind rather than cash in order to eliminate chances of misappropriation and mis-utilisation. This would help in improving their financial muscle and productivity.

Secondly, it is recommended that government should adopt inflation controlling monetary policy and cost restricting fiscal policy to manage or curb inflation. These should be done moderately in order not to compound the menace of unemployment in the country. In effect, government should relate increased wages to increased productivity. Reducing indirect taxes or levies on raw materials and finished goods will also go a long way to reduce cost of production and prices of goods. It is worth stating that these measures should be geared towards increasing food production, stabilizing prices of agricultural inputs/products and improve technological intervention through persistent monetary and regulatory measures without hampering employment. Thus, these policy initiatives should strengthen the economy and confidence of stakeholders in government policies and through the multiplier effect, Ghana may get numerous benefits through increasing TFPG of agriculture.

Thirdly, it is recommended that secondary school education should be government's priority agenda. In this regard, specific steps should be taken to promote secondary education. The proper implementation of "free SHS" which has been championed by the government of the day and further investment in the education sector is expected to improve TFPG of agriculture significantly in the long-run. In effect, budgetary allocation to the education ministry should be increased to aid improve secondary school enrolment and development of human capital in general.

In addition, a trade policy that seeks to expand the volumes of trade should be government's priority in promoting agricultural productivity. This means that government should promote trade liberalization by opening up its boarders and engaging in further trade of agricultural products. Advances should be made in discovering new markets for trading agricultural commodities. In the same vein education on emerging requirements of trade liberalization should be expanded to ensure compliance. Additionally, extensive diplomatic strategies should be embraced to promote the image of Ghanaian commodities in the international market. It is also recommended strongly that farmers should be made to benefit wholly from the optimal share of trade in order for them to be motivated to enhance agricultural productivity and TFPG.

Government should also embark on policies that ensures stable exchange rate regime. Dollarization of the economy should be eliminated and stringent measures should also be put in place to regulate the entry and exit of dollars into the economy. These interventions are necessary to reduce exchange rate volatility in Ghana and to ward off future speculative attacks. Thus, policy makers should keep a stable macroeconomic environment, if they want to lessen the detrimental effects of exchange rate volatility on agricultural and macroeconomic performance.

Furthermore, it is recommended that Government expenditure on infrastructure be increased to ensure timely availability of inputs and easy access to markets for agricultural commodities. This will help improve resource use efficiency and hence productivity. Focus of government should also be directed at improving infrastructure through improved storage system and roads, mainly linking up farming communities to the market centres. Joint partnership (Public-private) may be a productive choice in this respect. This would guarantee continuity of infrastructural developments in Ghana.

Finally, activities and policies that will mitigate the negative effect of climate change must be advanced in order to ensure consistent rainfall. An afforestation and reforestation programme of the government and civil society would go a long way to help in that direction. In this regard, youth in afforestation and 'green Ghana' under the Nation Builders Corps (NABCO) should be promoted. Also, the use of Liquefied Petroleum Gas (LPG) and affordability of same should be promoted.

5.3 Suggestions for future studies

The research can be developed further in the following ways:

To start with, the Solow index, which was used in estimating TFP, needs to be tested more carefully by comparing its results to DEA results. Future research should consider using different approaches in estimating TFP in Ghanaian agriculture. This was not possible in the current study because of data issues.

Secondly, future studies should be extended to measure and compare TFPG of the various sectors of the Ghanaian economy.

Thirdly, this research used general government final consumption expenditure as a proxy for infrastructural development which may not be a true reflection of the significance of infrastructural expenditure on TFPG in Ghanaian agriculture. Having access to the actual data on infrastructural expenditure and other proxied variables would be significant in overcoming this problem.

In addition, future studies should consider the role of TFPG in poverty reduction in Ghana. It is expected that growth in TFP will result in poverty reduction in Ghana.

Last but not the least, future research should take a critical look at the association between agricultural total factor productivity and industrialization and economic growth. No study has been done in this area at the time of writing this thesis. The outcome could be of great impact and significance in structuring the economy.

REFERENCES

Abukari A. T., Oztornaci, B. & Veziroglu P, (2016). Total factor productivity growth of Turkish agricultural sector from 2000 to 2004: Data envelopment malmquist analysis productivity index and growth accounting approach. *Journal of development and Agricultural Economics,* 8(2).

Acemoglu, D. & Zilibotti F., (1999), "Productivity Differences", NBER Working Paper No. 6879, Cambridge, MA: NBER.

Acemoglu, D. (2008). Introduction to Modern Economic Growth. Retrieved from: https://press.princeton.edu/titles/8764.html

Adams, Jr. R. (1993). "Non-Farm Income and Inequality in Rural Pakistan". *Pakistan Development Review*, 32(4), 1187-1198.

Aigner, D.J. & Chu, S.F. (1968) On Estimating the Industry Production Function. *American Economic Review*, 58, 826-839.

Aigner, D., Lovell C.A.K., &Schmidt. P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics* 6 (1977) 21-37.

Agbola F. W. & Maylene Y. D. (2005), "Time Series Estimation of Import Demand Functions for Pulses in India," *Journal of Economic Studies*, 32(2), 146-157.

Akinlo, A. E. (2005). "Impact of Macroeconomic Factors on Total Factor Productivity in Sub-Saharan African Countries". Research Paper No. 2005/39, *World Institute for Development Economics Research,* UNU.

Al-Azzam A. & David H. (1997). Estimating the Demand for Energy in Jordan: A Stock-Watson Dynamic OLS (DOLS) Approach,*Mimeo,* 16 pages.

Alauddin, M., Headey, D., &Rao, D. S. P., (2005), "Explaining Agricultural Productivity Levels and Growth: An International Perspective", *Centre for Efficiency and Productivity Analysis*, Working paper series no. 02

Ali, S., (2004), "Total factor productivity growth in Pakistan's agriculture: 1960-1996", *The Pakistan Development Review,* 43(4), 493-513.

Ali, S. (2005). "Total Factor Productivity Growth and Agricultural Research and Extension: An analysis of Pakistan's Agriculture, 1960-1996". *The Pakistan Development Review*, 44(4), 729-746.

Ali, A., Khalid, M. & Muhammad, A., (2008), "Total Factor Productivity (TFP) Growth in Agriculture in Pakistan: Trends in Different Time Horizons", *Pakistan Journal of Agricultural Science*, 45(4), 508-513.

Ali, A., K. Mushtaq, M. Ashfaq, & M. A. Raza (2009). An Analysis of Productivity Growth of Agriculture in Pakistan 1971-2006. *J. of Agric. Res*,47(4), 439-450.

Ali, A., Mushtaq K., Ashfaq M., Abedullah & Dawson P.J. (2012). Macro Determinants of Total Factor Productivity Growth of Agriculture in Pakistan. *Pakistan Journal of Applied Economics*, *Applied Economics Research Centre*, vol. 22.

Alimi, R. S. (2013). Testing Augmented Wagner's Law for Nigeria Based on Cointegration and Error-Correction Modelling Techniques. http*://mpra.ub.uni-muenchen.de/52319/*

Alimi R. S., Bayo F., Gabriel K. O. & Gbenga F. O. (2015). Bounds Testing Approaches to the Analysis of Macroeconomic Relationships in Nigeria. *European Journal of Business and Management*, 7(8).

Amarjit S. S. & Supreet K., (2013). Growth Accounting Analysis in India with Specific Reference to the Economies of Punjab and Haryana. *Journal of Income and Wealth*, 35(2).

Atiyas I. & Bakis O. (2013). Aggregate and Sectoral TFP Growth in Turkey: A growth Accounting Exercise. *Sabancı Üniversitesi, Orta Mahalle, Üniversite Caddesi* No: 27 34956 Tuzla, ˙Istanbul.

Aymen F, Boubaker D, Aden A-H, Samia, A.& Ali I. (2015). Approaches to Total Factor Productivity Measurements in the Agriculture Economy. *CGIAR*

Avila A. F. D. & Evenson R. E. (2010). "Total Factor Productivity Growth in Agriculture: The Role of Technological Capital," *Handbook of Agricultural Economics*.

Baba, Y., Hendry, D. F., & Starr, R. M. (1992). The demand for m1 in the USA, 1960–1988. *The Review of Economic Studies,* 59, 25–61. http://dx.doi.org/10.2307/2297924

Bahmani-Oskooee, M. & Tankui, A. (2008). The black market exchange rate vs. the official rate in testing PPP: which rates fosters the adjustment process? *Economics Letters*, 99, 40-43.

Balassa, B. (1964). "The Purchasing Power Parity Doctrine: A Reappraisal." *Journal of Political Economy* 72 (December): 584–96

BANK-OF-GHANA-Agric.-policy-2004. Retrieved from: http://agricinghana.com/wp-content/uploads/2017/07/BANK-OF-GHANA-Agric.-policy-2004-Final.pdf

Banker R. D., Charnes A. and Cooper W. W. (1984). "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis." *Management Science* 30(9): 1078-1092.

Barro R. J. (1991). Economic Growth in a Cross Section of Countries. *The Quarterly Journal of Economics*, 106(2).

Battese, G. E. & Coelli T. J. (1992). Frontier production functions, technical efficiency and panel data: With application to paddy farmers in India, *Journal of Productivity Analysis*,3, 153-169.

Battese, G. E. & Coelli, T. J., (1995), "A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data", *Empirical Economics*, 20, 325-332.

Bawumia, M. (2012). "The State of the Ghanaian Economy." *Ferdinand O. Ayim Memorial Lecture*, May 2, 2012, Accra.

Belloumi, M., & Matoussi, M.S., (2009). "Measuring agricultural productivity growth in MENA countries" *Journal of Development and Agricultural Economics*, 1(4), 103-113.

Benin, S. (2016). Agricultural productivity in Africa. *International Food Policy Research Institute (IFPRI)*. Washington, D.C.

Bernanke, B.S., & Gurkaynak, R .S. (2001): "Is Growth Exogenous? Taking Mankiw, Romer, and Weil Seriously", in: B.S. Bernanke, Kenneth Rogoff (eds) NBER Macroeconomics Annual 2001, Cambridge: *MIT Press*.

Bharati, P., &Fulginiti, L., (2007), "Institutions and Agricultural Productivity in Mercosur", *Institutions and Economic Development,* Viçosa, Brazil.

Bregman, A., & Marom, A. (1993). Causes of growth in the business sector in Israel, 1958-1988. *Bank of Israel Discussion Paper, 93*.

Breisinger, C., Diao, X., Thurlow, J., & Hassan, R. M. A. (2011). Potential impacts of a green revolution in Africa—the case of Ghana. *Journal of international development*, 23(1), 82-102.

Breisinger, C., Diao, X., Kolavalli, S., Al-Hassan, R. M., & Thurlow, J. (2011). A new era of transformation in Ghana: Lessons from the past and scenarios for the future. *Intl Food Policy Res Inst.*, 171.

Camacho-Gutierrez, P. (2010). Dynamic OLS estimation of the U.S. import demand for Mexican crude oil. *MPRA*. Retrieved from*: https://mpra.ub.uni-muenchen.de/30608/*

Capalbo, S.M., & Antle, J.M. (1988). Agricultural Productivity Measurement and Explanation (edited). Washington, D.C.: Resources for the Future.

Caves, D. W., Christensen L. R. & Diewert W. E. (1982). The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity. *Econometrica*, 50(6), 1393–1414.

Chand, R., Kumar, P., & Kumar, S. (2012). Total Factor Productivity and Returns to Public Investment on Agricultural Research in India. *Agricultural Economics Research Review*, 25(2), 181-194.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). A Data Envelopment Analysis Approach to Evaluation of the Program Follow through Experiment in US Public School Education (No. MSRR-432). Carnegie-Mellon Univ Pittsburgh Pa *Management Sciences Research Group*.

Chen, E. K. Y. (1997). The Total Factor Productivity Debate: Determinants of Economic Growth in East Asia. *Asian-Pacific Economic Literature*, 11, 18-38.

Christensen, L R. (1975). Concepts and Measurement of Agricultural Productivity. *American Journal of Agricultural Economics*, 57(5), 910-15.

Christensen, L., Jorgenson, D. & Lau, L. (1973) Transcendental Logarithmic Production Frontiers. *Review of Economics and Statistics*, 55, 28-45

Clark, G. (2008). A farewell to alms: a brief economic history of the world (Vol. 25). Princeton University Press.

Cobb, C. W. & Douglas, P. H. (1934). "The Theory of Wages". New York: *Macmillan Co.*,

Coe, D. T., Helpman, E., & Hoffmaister, A. W. (1997). North-south R & D spillovers. *The Economic Journal*, 107(440), 134-149.

Coelli, T. (1995). Estimators and hypothesis tests for a stochastic frontier function: A Monte Carlo analysis. *Journal of productivity analysis*, 6(3), 247-268.

Coelli, T. J. (1996), "Measurement of Total Factor Productivity Growth and Biases in Technological Change in Western Australian Agriculture", *Journal of Applied Econometrics*, 11(1), 77–91.

Coelli T. J., Prasada R. D. S., O"Donnell C. J., & Battese G. E. (2006). An Introduction to Efficiency and Productivity Analysis, 2nd Edition, *Springer, New York*, 366 pp.

Coelli, T. J. & Rao, D. (2005). Total factor productivity growth in agriculture: a Malmquist index analysis of 93 countries, 1980-2000. *Agricultural Economics*, 32(s1). *http://dx.doi.org/10.1111/j.0169-5150.2004.00018.x*

Coelli, T. J., Rao, D. S. P., O'Donnell, C. J. & Battese, G. E. (2005). An Introduction to Efficiency and Productivity Analysis, *New York, Springer*.

Coelli, T. J., Rao, D. S. & Prasada, D., (2003), "Total Factor Productivity Growth in Agriculture: A Malmquist Index Analysis of 93 Countries, 1980-2000", *CEPA Working Papers*, School of Economics, University of Queensland, Brisbane, Australia.

Cooke, E., Hague, S., & McKay, A. (2016). The Ghana poverty and inequality report: *Using the 6th Ghana living standards survey. New York: UNICEF*.

Daly, D. J. (1972). Combining inputs to secure a measure of Total Factor Inputs. *The Review of Income and Wealth*, 18, 27-53.

Davidson, J. E. H., Hendry, D. F., Srba, F. & Yeo, S. (1978) Econometric Modelling of the Aggregate Time-Series Relationship Between Consumers' Expenditure and Income in the United Kingdom. *The Economic Journal*, 88, 661-692.

Desai, B. M. & Namboodiri, N. V. (1997). Determinants of Total Factor Productivity in Indian Agriculture, *Economic and Political Weekly*, 32(52), 165–171.

Dev, M. S. (2012). Policies for Raising Agricultural Growth and Productivity in India. IGIDR Proceedings/Projects Series.

Dhehibi, B. (2015). Approaches to Total Factor Productivity Measurements in the Agriculture Economy.

Dhehibi, B., El-Shahat, A. A. I. A., Frija, A., & Hassan, A. A. (2016). Growth in Total factor productivity in the Egyptian agriculture sector: Growth accounting and econometric assessments of sources of growth. *Sustainable Agriculture Research*, *5*(526-2016-37743).

Diao, X., Hazell, P., Resnick, D. & Thurlow, J. (2007). The Role of Agriculture in Development: Implications for Sub-Saharan Africa. *Research Report 153*. http://dx.doi.org/10.2499/9780896291614rr153

Diao, X. (2010). Economic Importance of Agriculture for Sustainable Development and Poverty Reduction: Findings from a Case Study of Ghana. *International Food Policy Research Institute*. Retrieved from http://www.oecd.org/agriculture/agricultural-policies/46341169.pdf

Diallo, I. A. (2013). Exchange Rate Policy and Productivity. Economies et finances. Université d'Auvergne - *Clermont-Ferrand I*, 2013. Français. tel-00997038

Dickey, D. A. & Fuller, W. A. (1979), "Distribution of the Estimators for Autoregressive Time Series With a Unit Root," *Journal of the American Statistical Association*, 74, 366, 427-431.

Dickey, D. A. & Fuller, W. A. (1981). "Likelihood Ratio Statistics for Autoregressive Time Series with Unit Roots". *Journal ofEconometrica*, 49, 1057-72.

Diewert, W. E. (1992a). Fisher ideal output, input, and productivity indexes revisited. *Journal of Productivity Analysis*, 3(3), 211-248.

Diewert, W. E. (1992b). The measurement of productivity. *Bulletin of Economic Research*, 44(3), 163-198.

Diewert, W. E. & Nakamura A. O. (2006). The Measurement of Aggregate Total Factor Productivity Growth. In: Heckman JJ, Leamer EE, eds., *Handbook of Econometrics* 6. Amsterdam:

Dooley, M. P. (1988). Capital flight: a response to differences in financial risks. *Staff Papers*, 35(3), 422-436.

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

Edwards, S. (1988b). The determination of equilibrium real exchange rate, *UCLA Working Paper* Number 508.

Edwards, S.(1998). Capital flows, real exchange rates, and capital controls: Some Latin American experiences, *NBER Working Papers* 6800.

Engle, R. F. & C. W. J. Granger (1987). "Cointegration and Error Correction: Representation, Estimation and Testing". *Journal of Econometrica*, 55, 251-276.

Enu P. & Attah-Obeng P. (2013). Which Macro Factors Influence Agricultural Production In Ghana*? Academic Research International*, 4(5).

Fan S., P. Hazel, & T. Sukhadeo (1999). "Linkages between Governments Spending,Growth and Poverty in Rural India". Research Report No 110. *International Food PolicyResearch Institute:* Washington D.C., USA.

Fan, S., & X. Zhang (2004). "Infrastructure and Regional Economic Development inRural China". *China Economic Review*, 15(2), 203-214.

FAO (2015). Country fact sheet on food and agriculture policy trends. (2015) (1st ed.). Rome. Retrieved from: http://www.fao.org/3/a-i4490e.pdf

FAO, (2013). World Food and Agriculture. Rome: Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/docrep/018/i3107e/i3107e00.htm

FAO (2014), FAOSTAT database. http://www.fao.org/.

FAO, (2014). Food andAgriculture Organization, 2014. Cereal Supply and Demand Brief-5 July 2012.

Fare R, Grosskopf S, Norris M. & Zhang Z. (1994). Productivity Growth, Technical Progress, and Efficiency Changes in Industrialized Countries", *Am. Econ. Rev*. 84(1), 66-83.

Färe, R., Lovell, C. K. & Zieschang, K. (1983). Measuring the technical efficiency of multiple output production technologies. In Quantitative Studies on Production and Prices (pp. 159-171). Physica, Heidelberg.

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society:* Series A (General), 120(3), 253-281.

Fisher, R. J. (1993). Social desirability bias and the validity of indirect questioning. *Journal of consumer research*, 20(2), 303-315.

Fuglie, K. O. (2015). "Accounting for Growth in Global Agriculture," *Bio-based and Applied Economics* 4(3), 221-54.

Fuglie, K. & Rada, N. (2013). Resources, Policies, and Agricultural Productivity in Sub-Saharan Africa. *USDA-ERS Economic Research Report*, (145).

Fulginiti, L.E., Perrin, R. K. & Yu, B., (2004). "Institutions and agricultural productivity in Sub-Saharan Africa," *Agricultural Economics*, Blackwell, 31, 169-180.

Ghana Budget. (2017). Budget Statement and Economic Policy of the Government of Ghana for the 2017 Financial Year (1st ed.). Accra: Ministry of Finance. Retrieved from http://www.mofep.gov.gh/

Ghana Budget. (2019). Mid-Year Fiscal Policy Review of the 2019 Budget Statement and Economic Policy, and Supplementary Estimates of the Government of Ghana for the 2019 Financial Year. Accra: Ministry of Finance. Retrieved from http://www.mofep.gov.gh/

Ghana Statistical Service (2016), revised 2015 annual GDP Bulletin. Accra: Ghana. Retrieved from http://www.statsghana.gov.gh/

Ghose, A., & Bhattacharyya, D. (2011). Total Factor Productivity Growth and its Determinants for West Bengal Agriculture. *Asian Journal of Agriculture and Development*, *8*(1362-2016-107703), 39.

Greene, W. H. (2000). Econometric Analysis. New Jersey: *Prentice-Hall, Inc*.

Gregory, A. W. and Hansen, B. E. (1996). Residual-based tests for cointegration in models with Regime Shifts. *Journal of Econometrics,* 70, 99-126.

Gujarati, D. N. (2009). Basic econometrics. *Tata McGraw-Hill Education*.

Hallam, D., & R. Zanoli. 1993. Error Correction Models and Agricultural Supply Response. *European Review of Agricultural Economics*,20, 151-66.

Halicioglu, F. (2007). Residential electricity demand dynamics in Turkey. *Energy economics*, 29(2), 199-210.

Hamid, K., & Ali, Y. Q. (2012). Investigating the Total Factor Productivity in Agricultural Sector Using Growth Accounting in Iran. *European Journal of Experimental Biology*, 2(1), 17-23.

Harris, R. G.: 2001, Is there a case for exchange rate Induced productivity changes, *Mimeo*, Department of Economics, Simon Fraser University, Canadian Institute for Advanced Research.

Harris R & Sollis R. (2003). Applied time series modelling and forecasting. United Kingdom, *Wiley*.

Haug, A. (2002). Temporal aggregation and the power of cointegration tests: a MonteCarlo study, *Oxford Bulletin of Economics and Statistics*, 64, 399-412.

Hayami, Y. & Ruttan, V. W. (1985). Agricultural Development: An International Perspective, John Hopkins Studies in Development, Baltimore: *John Hopkins University Press*.

Headey, D. D., Rao, D. P., & Alauddin, M. (2005). Explaining Agricultural Productivity Levels and Growth: An International Perspective: *School of Economics*, University of Queensland, Australia.

Hicks, J. R. (1961). The measurement of capital in relation to the measurement of other economic aggregates. In The theory of capital (pp. 18-31). Palgrave Macmillan, London.

Ho, B. D. (2012). Total factor productivity in Vietnamese agriculture and its determinants. *University of Canberra*.

Holden, D. & Perman, R. (1994). Unit Roots and Cointegration for the Economist, in Rao, B. B., Cointegration for the Applied Economists, *St. Martin's Press*, New York.

Huffman, W. E. & Evenson, R. E. (2005). New Econometric Evidence on Agricultural Total Factor Productivity Determinants: Impact of Funding Composition. *Working Papers Series No.03029. Iowa, Department of Economics*, Iowa State University.

Im, K.S., Pesaran, M.H. & Shin, Y., (2003). "Testing for unit roots in heterogeneous panels", *Journal of Econometrics*, 115, 53-74

Isaksson, A. (2007). Determinants of Total Factor Productivity: A literature review. Mimeo, Vienna: UNIDO.

Johanson, S. (1988). "Statistical Analysis of Cointegrating Vectors". *Journal of Economic Dynamics*, 2(3), 231-254.

Johansen, S. (1992). Cointegration in partial systems and the efficiency of single-equation analysis. *Journal of Econometrics*, 52, 389-402.

Johansen, S. & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration with application to the demand for money. *Oxford Bulletin of Economics and Statistics*, 52, 169-210.

Johnston, B. F. & Mellor, J. W. (1961). The Role of Agriculture in Economic Development. *The American Economic Review*, 51, 566-593.

Kalirajan, K. P., & Obwona, M. B. (1994). Frontier production function: The stochastic coefficients approach. *Oxford Bulletin of Economics and Statistics*, 56(1), 87-96.

Kalirajan, K., Obwona, M., & Zhao, S. (1996). A Decomposition of Total Factor Productivity Growth: The Case of Chinese Agricultural Growth before and after Reforms. *American Journal of Agricultural Economics*, 78(2), 331-338.

Kannan, E. (2011). Total Factor Productivity Growth and Its Determinants in Karnataka Agriculture. *ISEC Working Paper* 265, 1-19.

Kathuria, V., Rajash, S. N. R., &Kunal, S. (2012). Productivity measurement in Indian Manufacturing: A comparison of alternative methods. *J. Quant. Econ*. 11(1-2).

Kathuria, V., Raj, R.S.N., &Sen K. (2013). Productivity measurement in Indian manufacturing: A comparison of alternative methods. *Journal of Quantitative Economics*, 11(1&2), (Combined).

Kaur, J., & Sethi, P. (2013). Evaluation of fuzzy inference system in image processing. *International Journal of Computer Applications*, 68(22).

Kendrick, J. W. (1961). Productivity Trends in the United States, Princeton University Press, Princeton.

Khan, S. (2006). "Macro Determinants of Total factor Productivity in Pakistan". *Working Paper Series #10,* State Bank of Pakistan, Karachi.

Kibaara, B., Ariga, J., Olwande, J., & Jayne, T. S. (2009). Trends in Kenyan agricultural productivity: 1997-2007. Egerton University. *Tegemeo institute of agricultural policy and development.*

Kolavalli, S., Robinson, E., Ngeleza, G. & Asante, F. (2012). Economic transformation in Ghana: Where will the path lead? *Journal of African Development*, 14(2), 41-78.

Kormendi, R. & Meguire P. (1985). Macroeconomic determinants of growth, *Journal of Monetary Economics* 16(2), 141-63.

Konadu-Agyemang, K. (2000). The best of times and the worst of times: structural adjustment programs and uneven development in Africa: the case of Ghana. *The Professional Geographer*, *52*(3), 469-483.

Kowalski, P. A. (2003). Nominal and real convergence in alternative exchange rate regimes in transition countries: implications for the EMU Accession. *CASE Network Studies and Analyses*, (270).

Kwakwa P. A. & Alhassan H. (2018).The Effect of Energy and Urbanisation on Carbon Dioxide Emission: Evidence from Ghana

Kwiatkowski, D., Phillips, P. C. B., Schmidt, P. & Shin, Y. (1992). Testing the Null of Stationarity against the Alternative of a Unit Root: How Sure Are We That Economic Time Series Have a Unit Root? *Journal of Econometrics,* 54, 159– 178.

Lafrance, R., & Schembri, L. L., (2000). The Exchange Rate, Productivity, and the Standard of Living. *Bank of Canada Review*. 2000, 17-28.

Lensink, R., Hermes, N., & Murinde, V. (1998). The effect of financial liberalization on capital flight in African economies. *World Development*, *26*(7), 1349-1368.

Levine, R., & Renelt, D. (1992). A sensitivity analysis of cross-country growth regressions. *The American economic review*, 942-963.

Lewis, A. W. (1980). "The Slowing Down of the Engine of Economic Growth". *American Economic Review*, 70, 555-564.

Leybourne, S. J., & Newbold, P. (2003). Spurious rejections by cointegration tests induced by structural breaks. *Applied Economics*, *35*(9), 1117-1121.

Mankiw, N.G., Romer, D. & Weil D. N. (1992), "A Contribution to the Empirics of Economic Growth", *Quarterly Journal of Economics*, 107.

Mayer, J. (2001), "Technology Diffusion, Human Capital and Economic Growth in Developing Countries", *Discussion Papers, No. 154, Geneva: United Nations Conference on Trade and Development.*

Meeusen, W., & van Den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International economic review*, 435-444.

Miller, S. M., & Russek, F. S. (1997). Fiscal structures and economic growth: international evidence. *Economic Inquiry*, *35*(3), 603-613.

Miller, S. M., & Upadhay M. P. (2000). "The Effect of Openness, Trade Orientation, and Human Capital on Total Factor Productivity". *Journal of Development Economics*, 63, 399-423.

Ministry of Food and Agriculture (2007) "Agriculture in Ghana: facts and figures," Produced by the Statistics, Research and Information Directorate, Accra.

Ministry of Food and Agriculture (2010), "Agriculture in Ghana: facts and figures," *Produced by the Statistics*, *Research and Information Directorate*, Accra.

MoFA. (2013). National Irrigation Policy, Strategies and Regulatory Measures. *Ghana Irrigation Development Authority, Ghana.* Retrieved from: *mofa.gov.gh/site/wp.../07/GHANA-IRRIGATION-DEVELOPMENT-POLICY1.pdf*

MoFA. (2013). Agriculture in Ghana: Facts and Figures (1st ed.). Accra: Ministry of Food and Agriculture. Retrieved from *http://mofa.gov.gh/site/wp-content/uploads/2014/03/agriculture-in-ghana-ff-2012-nov2013.pdf*

MoFA. (2016). Agriculture in Ghana: Facts and Figures (2015) (1st ed.). Accra: *Ministry of Food and Agriculture*. Retrieved from http://mofa.gov.gh/site/

MoFA. (2017). Planting For Food and Jobs: Strategic Plan for Implementation (2017-2020). Retrieved from http://mofa.gov.gh/site/wp-content/uploads/2018/03/PFJ%20document%20New%20New.pdf

MoFA (2018). Agricultural Sector Progress Report 2017, *Adwinsa Publications Ghana Limited*, Ghana

Mohammadrezazadeh, N., Karbasi, A. & Purmoghaddam, A., (2012), "The Analysis of productivity growth of all production Elements in Iran,s Agriculture", *8th conference of Agricultural Economics of Iran*, Shiraz, Iran.

Mohan, G. & Matsuda, H., (2013). “Regional level Total Factor Productivity Growth in Ghana Agriculture”. *Journal of economics and sustainable development*, 4, 5.

Mohan, G., Matsuda, H., Donkoh S. A., *et al*. (2014). “Effects of Research and Development Expenditure and Climate Variability on Agricultural Productivity growth in Ghana”. *Journal of Disaster Research*, 9, 4.

Moorsteen, R. H. (1961). On measuring productive potential and relative efficiency. *The Quarterly Journal of Economics*, *75*(3), 451-467.

Murthy, K. V. B., (2004). Arguing a Case for Cobb-Douglas Production Function. *Review of Commerce Studies*, 20-21(1). January-June, 2002. Available at SSRN: https://ssrn.com/abstract=598082

Nachega, J. & T. Fontaine (2006). “Economic Growth and Total factor Productivity in Niger”. International Monetary Fund (IMF), working paper, No. WP/06/208.

Nankani, G. T. (2009). *The Challenge of Agriculture in Ghana: What is to be Done?*. Institute for Democratic Governance.

Newey, W. K., & West, K. D. (1987). r= k. This orthogonality condition can be employed to form a generalized method of moments (GMM, Hansen (1982)) estimator of 6* by choosing 6) as the solution to. *Econometrica*, *55*(3), 703-708.

Njikam, O., Binam, J. N.& Tachi, S. (2006). "Understanding Total Factor Productivity Growth in Sub Saharan Africa Countries". *WP No.2006/3, Secretariat for Institutional Support for Economic Research in Africa.*

Odhiambo, W., Nyangito, H., & Nzuma, J. (2003). Measuring and analysing agricultural productivity in Kenya: A review of approaches. *Kenya Institute for Public Policy Research and Analysis*

Olopoenia, R. A. (2000). Capital flight from Uganda, 1971-94: Estimates, causes and consequences. *External debt and capital flight in sub-Saharan Africa*, *238*.

Ozden, A. (2014). Total factor productivity growth in Turkish agriculture: 1992-2012. *Bulgarian Journal of Agricultural Science*, *20*(2), 469-473.

Pasha, H. A., Pasha, A. G. &Hyder,K. (2002). "The Slow Down of the Growth of Total Factor Productivity in Pakistan". *Social Policy and Development Centre (SPDC),* Karachi, Pakistan, Research Report No. 44.

Pedroni, P. (2000). "Fully modified OLS for heterogenous cointegrated panels", *Advances in Econometrics*, 15, 93-130.

Perron, P. (1989). The great crash, the oil price shock, and the unit root hypothesis. *Econometrica: Journal of the Econometric Society*, 1361-1401.

Perron, P. (1997). Further evidence on breaking trend functions in macroeconomic variables. *Journal of econometrics*, *80*(2), 355-385.

Peseran, M. H. & Peseran, B. (1997). Working with Microfit 4.0: Interactive Econometric Analysis. Oxford: Oxford University Press.

Pesaran, M. H. & Shin, Y. (1999). An autoregressive distributed lag modelling approach to cointegration analysis. Chapter 11 in S. Strom (ed.), *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*. Cambridge University Press, Cambridge. (**Discussion Paper version**.)

Pesaran, H., Shin Y. & Smith, R. (1999). Pooled mean group estimation of dynamic heterogeneous panels, *Journal of the American Statistical Association*, 94, 621-634.

Pesaran, M. H., Shin, Y. & Smith, R. P. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16, 289-326.

Phillips, P. C.B. (1987), "Time Series Regression with a Unit Root," *Econometrica*, 55(2), 277-301.

Phillips, P.C.B. & Perron, P. (1988). "Testing for a Unit root in Time Series Regression", *Biometrika*, 75, 335-346.

Porter, M.E. (1990). The Competitive Advantage of Nations, New York, NY: *The Free Press*.

Ragasa, C., Chapoto, A. & Kolavalli, S. (2014). Maize productivity in Ghana,*Intl Food Policy Res Inst.*, 5.

Deolalikar, A. B., Evenson, R. E., & Ranis, G. (1990). *Private inventive activity in Indian manufacturing: its extent and determinants*. Economic Growth Center, Yale University.

Rao, D.S., Prasada, C.T., & Alauddin, M., (2004), "Agricultural productivity growth, employment and poverty in developing countries, 1970-2000", Centre for Efficiency and Productivity Analysis (CEPA), *Employment Strategy Paper no. 9/2004, School of Economics*, University of Queensland, Brisbane, Australia.

Rodrik, D. (2010): "Structural Transformation and Economic Development" TEPAV: Ankara.

Rosegrant, M. W., & Evenson, R. E. (1992). Agricultural Productivity and Sources of Growth in South Asia. *American Journal of Agricultural Economics,* 74(3), 757-761.

Rosegrant, M.W. & Evenson, R.E. (1995), "Total Factor Productivity and Sources of Long–Term Growth in Indian Agriculture", EPTD Discussion Paper No. 7*, International Food Policy Research Institute,* Washington DC.

Sachs, J. (2006). The end of poverty: economic possibilities for our time. *Penguin*.

Saikkonen, P., & Lütkepohl, H. (2000). Testing for the cointegrating rank of a VAR process with structural shifts. *Journal of business & economic statistics*, *18*(4), 451-464.

Saikia, D. (2014). Total Factor Productivity in Agriculture: A Review of Measurement Issues in the Indian Context. *Romanian Journal of Regional Science*, 8,(2).

Sarpong E. O. (1986). Drought in Ghana. *Singapore journal of Tropical Geography*.7(2).

Seini A.W., (2002) "Agricultural Growth and Competitiveness under Policy Reforms in Ghana". *ISSER Publication* N0. 61, 2002

Senhadji, A. (1999). Sources of economic growth: an extensive growth accounting exercise. *IMF Staff Papers*, 45(2), 236-268

Simar, L., & Wilson, P. W. (1998). Sensitivity analysis of efficiency scores: How to bootstrap in nonparametric frontier models. *Management science*, *44*(1), 49-61.

Sheng, Y., & Chancellor, W. (2019). Exploring the relationship between farm size and productivity: Evidence from the Australian grains industry. *Food Policy*, *84*, 196-204.

Simar, L., & Wilson, P. W. (1999). Estimating and bootstrapping Malmquist indices. *European Journal of Operational Research*, *115*(3), 459-471.

Solow, R. M. (1957) Technical Change and the Aggregate Production Function. *Review of Economics and Statistics*, 39, 312-320.

Stock, J. H., & Watson, M. (1993). A simple estimator of cointegration vectors in higher order integrated systems. *Econometrica*, 61, 783–820. http://dx.doi.org/10.2307/2951763

Suphannachart, W., & Warr, P. (2012). Total Factor Productivity in Thai Agriculture: Measurement and Determinants. *Productivity growth in agriculture: An international perspective*, 215.

Tahamipour, M. (2008). Estimating capital stock time series in agricultural sector for 1959-2004.

Tayebi, Z., & Fulginiti, L. E. (2016). *Agricultural productivity and climate change in the greater Middle East* (No. 1376-2016-109812).

Thirtle, C., Lin, L. & Piesse, J. (2003). The Impact of Research-Led Agricultural Productivity Growth on Poverty Reduction in Africa, Asia and Latin America. *World Development*, 31, 1959-1975.

Timmer, C. P. (2002). Agriculture and economic development. *Handbook of Agricultural Economics*, *2*, 1487-1546.

Trindade, F. & Fulginiti, L. E., (2015). "Is there a Slowdown in Agricultural Productivity Growth in South America", *Agricultural Economics*, 46, 69-81.

Urata, S. & Yokota, K. (1994) Trade Liberalization and Productivity Growth in Thailand. *The Development Economies*, 32, 444-458.

Wagner, M. & J. Hlouskova (2010). The performance of panel cointegration methods: Results from a large scale simulation study. *Econometric Reviews* 29(2), 182–223.

Wang, J., Gao, F., & Wang, X. (2009). *Estimation of agricultural total factor productivity in China: A panel cointegration approach* (No. 1005-2016-79373, p. 2).

Wik, M., Pingali, P., & Broca, S. (2008). Global agricultural performance: past trends and future prospects. *Background paper for the WDR*.

World Bank (2007). Agriculture for Development. Washington, DC: The International Bank for Reconstruction and Development/the World Bank. Retrieved from http://siteresources.worldbank.org/INTWDR2008/Resources/WDR_00_book.pdf

World Bank (2018). World Bank Development indicators (WDI) – Ghana. http://data.worldbank.org/sites/default/files/wdi-2018-book.pdf

Zhang, X., & S. Fan (2001). "How Productive is Infrastructure? New Approach and Evidence from Rural India". EPTD Discussion Paper No. 84. Washington, D. C: International Food Policy Research Institute (IFPRI).

Zivot, E., & Andrews, K., (1992). Further Evidence on the Great Crash, the Oil Price Shock, and the Unit Root Hypothesis. *Journal of Business and Economic Statistics*, 10(10), 251-70.