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Investment Patterns in Agriculture and Their Impact on Agricultural Output in Selected African Countries

BY

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DECLARATION

I declare that this work titled "Investment Patterns in Agriculture and their Impact on Agricultural Output in Selected African Countries" was written by me. It has not been presented in any previous application for any degree of this or any other university. All citations and sources of information are clearly acknowledged by means of references.

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CERTIFICATION

We certify that this work titled "Investment Patterns in Agriculture and their Impact on Agricultural Output in Selected African Countries" was carried out by Oluwayemisi Oladunni Gbolade in the Department of Economics, Accounting, and Finance, College of Management Sciences under our supervision.

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Dr. O. S. Enilolobo   Date

(Supervisor)

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Mr. A. A. Ajibola   Date

(Head of Department)

DEDICATION

I dedicate this work to God Almighty for His grace, blessings, and benevolence all through my academic and professional career.

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ISSN No:-2456-2165

TABLE OF CONTENTS

ISSN No:-2456-2165

LIST OF TABLES

Table **Page**

ISSN No:-2456-2165

LIST OF FIGURES

ABSTRACT

The Food and Agricultural Organisation (FAO) of the United Nations categorises investments in agriculture as domestic private, domestic public, foreign private, and foreign public investments. The main objective of this study is to estimate the impact of the categories of investments in agriculture on agricultural output in Africa. The patterns of investments in agriculture in Africa, and the direction of causality between the investment categories in agriculture and agricultural output in Africa were also examined. Agricultural output index, agricultural gross fixed capital formation, general government expenditure on agriculture, public spending on agricultural research and development (R&D), foreign direct investments, and development flows to agriculture are prominent variables of the study. The data sources of these variables include the FAO of the United Nations, the International Food Policy Research Institute (IFPRI), and the United Nations Conference on Trade and Development (UNCTAD). The agricultural output model was constructed using balanced panel data on 36 member-countries of the African Union covering the period of 1980 - 2018. Three panel data models were evaluated for the study, namely, Pooled Ordinary Least Squares (Pooled OLS), Fixed-Effects (FE), and Random-Effects (RE) models, with the FE model emerging superior. The results reveal that foreign private investments (FPRI) are the largest source of investments in agriculture in Africa, followed by domestic private investments (DPRI), domestic public investments (i.e., domestic public investments in terms of general government expenditure on agriculture {DPGE} plus domestic public investments in terms of public spending on agricultural R&D {DPRD}), and foreign public investments (FPUI). Furthermore, with the exception of DPGE and FPUI, which are positively correlated with agricultural output, but statistically insignificant, the categories of investments in agriculture have a significant positive impact on agricultural output in Africa, with the order of significance being DPRI, DPRD, and FPRI. Finally, there is unidirectional causality between the investment categories in agriculture and agricultural output in Africa, with causality from investment category to agricultural output in the cases of DPRI, DPRD, FPRI, and FPUI, but the other way round in the case of DPGE. Based on these findings, agricultural development initiatives in Africa should be geared towards increasing domestic private sector participation in agriculture. Agricultural research and development (R&D) policy framework should be designed to focus on agricultural science and technology. An environment that is conducive for foreign investment should be created and sustained across Africa.

KEYWORDS: *domestic private, domestic public, foreign private, and foreign public investments in agriculture; and agricultural output in Africa.*

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The agricultural sector of African economies traditionally includes crop production, rearing of animals, fishery, and forest resources. Agriculture (along with its support industries) by and large still remains the backbone of Africa‟s domestic economy. On the continental level, agriculture contributes up to 16% of the gross domestic product (GDP) and employs about 52 % of the active population (ILOSTAT, 2019). Notwithstanding, Africa still holds 60% of the world‟s uncultivated arable land; thus, creating a unique opportunity that can be utilised to pursue the growth and economic development of the entire region (Idowu, 2015).

The growth of the agricultural sector in African economies can help address major development constraints, especially with respect to the issue of poverty (Hazell & Roell, 1983; Ravallion & Datt, 1996; Fan & Rao, 2003). In addition to poverty reduction, the growth of agriculture also has recognition for being an important tool in reducing economic inequality in developing countries (Ravallion & Chen, 2007; Fan, Kanbur, & Zhang, 2008; Dastagiri, 2010). Furthermore, countries that have made the transition to developed status did so by reducing poverty, and accomplished this task during periods of high agricultural growth (FAO, 2013).

Generally, there is poor government spending on agriculture in Africa (Somma, 2008). In a collective attempt to address this issue, African Heads of States under the auspices of the African Union met in Maputo, Mozambique in 2003, and pledged to expend 10% of their respective budgets on agriculture by 2008. The main objective was to grow the agricultural sector of their respective economies by 6% annually by the year 2015. To effect this pledge, the Comprehensive Africa Agriculture Development Programme (CAADP) was launched in 2003; however, the results over the years have been highly variable (Somma, 2008).

For instance, the NewAfrican (2014) reported that on average Ghana expended 9.1% of her budget on agriculture between 2003 and 2010, and realised 17 times more per capita output during that period. During the same period, Burkina Faso averaged 16.9% public spending on agriculture. This spending policy generated 235,000 agricultural jobs within the period. Also, Ethiopia averaged

15.2% of her budget on agriculture during this same period, resulting in an extra ordinary decline in extreme poverty by 49%.

On the other hand, Rwanda, during the aforementioned period was only able to increase her investments in agriculture between 2007 and 2009, albeit by 30%. Also, in Sierra Leone, agricultural spending increased from 1.6% to 9.9% only in 2010 (NewAfrican, 2014). According to the NewAfrican (2014), only 20% of Sub-Saharan African (SSA) countries have met the Maputo target. This percentage excludes Nigeria, whose average spending ranged between 1.3% and 7.4% between 2003 and 2010. To improve investments in agriculture in Nigeria, expenditure on agriculture must increase by 24% on average (Alpuerto, Diao, Salau, & Nwafor, 2009).

Investments can be defined as expenditures incurred with the intent to expand production, create employment opportunities, generate income, promote technological advancement, increase tax revenue, or create added-value (Sinha, 2017; Mengoub, 2018). The food and agricultural organisation (FAO) of the United Nations categorises investments in agriculture as domestic private, domestic public, foreign private, and foreign public investments (FAO, 2012).

According to the FAO (2012), the roles of private and public investors in agriculture are complementary in nature, and therefore not substitutable. In particular, the role of domestic private investors (e.g., small-scale farmers, co-operatives, corporations, and other farm businesses) is critical in designing any development strategy to promote investments in agriculture. This is because: (i) public resources only, cannot meet the investment requirements for agriculture; and (ii) the majority of the flows of investments in agriculture are sourced from small-scale farmers (FAO, 2012). Based on these reasons, domestic private investments are the key to meeting the objectives of food security, poverty reduction, and environmental sustainability in Africa (FAO, 2012).

The FAO (2012) also reported that the success of private investments in agriculture is dependent on the policies and flows of public investments. Governments must therefore create a condusive environment for investments in agriculture to thrive in order to encourage productive and socially responsible investments by private investors. A fundamental approach to achieving this is to direct scarce public resources towards the provision of vital and high-yielding public goods, such as roads infrastructure, energy infrastructure, irrigation infrastructure, storage systems, human capital formation, and agricultural research and development (FAO, 2012).

A holistic approach is to develop an investments policy framework that will promote investments in agriculture in Africa (OECD, 2013; FAO, 2013). The process of developing an investments policy framework requires a comprehensive understanding of the factors and conditions that drive investments. Adequate policies must then be assigned and implemented to promote and facilitate these factors and conditions (OECD, 2013; FAO, 2013).

1.2 Statement of the Research Problem

The efficient use of natural and human resources in developing the agricultural sector in Africa has been hindered by land degradation, climate change, ethno-religious conflicts and political unrest, botched policies, and exclusion of key stakeholders in the agricultural value chain (Mengoub, 2018). Notwithstanding, despite still being a net importer of agricultural commodities, Africa has in the past two decades experienced significant growth in agriculture (Mengoub, 2018).

In recent years, the causes of low agricultural output in Africa have been much debated. While many issues have been raised, the general consensus is that the decline of agricultural investments is at the helm of the issues impeding agricultural growth and productivity in Africa (Islam, 2011). According to the FAO (2012), the issue is not just insufficient public investments, but also the exclusion of private investments from the development strategies for African agriculture. In other words, private sector investments in agriculture are believed to have a positive impact on agricultural output in Africa.

The FAO (2012) also reported that public expenditures have higher socio-economic benefits when directed towards the provision of public goods, such as rural infrastructure and agricultural research and development. Taking irrigation infrastructure as a case in point, Africa is blessed with a total agricultural land area of about 1.13 billion hectares, but only about 15.6 million hectares (i.e., about 1.4%) are equipped for irrigation. In Central and South America, as well as in Asia, areas equipped for irrigation total 23 million and 1.6 billion hectares (i.e., 3.1% and 15% of total agricultural land area), respectively (Liang, 2008). Thus, it is not farfetched to state that relatively speaking, the African continent has the lowest rate of irrigation facilities. Mengoub (2018) opined that investments in new precision irrigation techniques, such as localised irrigation, will allow for better farm-water management and crop yield in Africa.

Evidence presented in research studies indicate that investments in agricultural research and development (R&D) significantly increase agricultural productivity, resulting in increased income, poverty reduction, increased food and nutrition security, and environmental sustainability (Evenson & Gollin, 2003; World Bank, 2007; IAASTD, 2008). However, the story is different for Africa, which compared to other continents has benefited less from agricultural R&D mainly because investments in the development of new technologies and the potential for technology spillovers are relatively low (Johnson & Evenson, 2000). For Africa to exploit the advantages of agricultural R&D, it will need to substantially increase its investments. Considering the time lag between investing in research and realising its rewards, African governments have a fundamental role to play in providing adequate and sustainable agricultural R&D funding that will create an environment in which agricultural innovation can thrive (Alston, Pardey, & Piggott, 2006).

Kalibata (2010) opined that foreign aid is capable of providing adequate and sustainable solutions to the needs of the African farmer, particularly in the areas of improved input resources, transport and storage systems, and agricultural credit. These provisions are expected to reduce significantly the estimated 40 - 60% postharvest losses incurred on an annual basis, boost agricultural productivity, increase incomes, and foster economic growth. Kalibata (2010) also reported that the initiatives of donor funding will be better realised if supported with domestically driven solutions.

The Sustainable Development Goals (SDGs), launched in September 2015 and operational in 2016, consists of seventeen development goals with the objectives to improve the livelihoods of people, improve the economies of nations, and sustain the environment for future generations by the year 2030 (SDG Report, 2016). With Africa having some of the world"s fastest growing economies, the prospects of the future are good for Africa in attaining the SDGs, especially SDG (i) "end poverty in all ramifications," and SDG (ii) "end hunger, achieve food security, and promote sustainable agriculture" (Sperling, Granoff, & Vyas, 2012).

The African Development Bank (AfDB), whose mission is to help reduce poverty and improve the living conditions of people on the continent, through its Green Growth programme promotes economic growth initiatives that are socially responsible and compatible with environmental sustainability. The Green Agriculture component of the programme is part of the banks development strategy for 2013 – 2022 to address the issue of poverty, cater to the food and nutritional needs of a growing population, and simultaneously minimise environmental degradation. This development strategy is consistent with SDGs (i) and (ii) of the United Nations (Sperling, Granoff, & Vyas, 2012).

However, SDGs (i) and (ii) cannot be achieved without necessary growth in agricultural output. Since output is unlikely to grow without investments, then there is need for African nation-states to invest substantially in agriculture in order to increase agricultural output. Thus, the underlying justification or motive of this study is to enable African nation-states realize SDGs (i) and (ii) of the United Nations, through increased investments in agriculture.

1.3 Research Questions

In light of the research problem of this study, the following research questions are raised:

(i) What are the patterns of investments in agriculture in Africa?

(ii) To what extent do the categories of investments in agriculture impact agricultural output in Africa?

(iii) What is the direction of causality between the investment categories in agriculture and agricultural output in Africa?

1.4 Research Objectives

The broad objective of this study is to analyse the impact of investments in agriculture on agricultural output in Africa. However, the specific research objectives of this study are to:

(i) Examine the patterns of investments in agriculture in Africa.

(ii) Estimate the impact of the categories of investments in agriculture on agricultural output in Africa.

(iii) Determine the direction of causality between the investment categories in agriculture and agricultural output in Africa.

1.5 Research Hypotheses

A priori, investments by being a component of national income will augment GDP. Correspondingly, investments in agriculture will augment agricultural output, since agricultural output is a component of GDP. Additionally, if the postulation is that investments in agriculture promote agricultural output, then this augmentation should be positive in nature. Based on this framework and the objectives of the study, below are the research hypotheses of the study stated in both null and alternative forms.

Null Hypotheses (H_0):

(i) Domestic private investments are the least source of investments in agriculture in Africa, followed by domestic public investments, foreign public investments, and foreign private investments.

(ii) The categories of investments in agriculture do not have a significant positive impact on agricultural output in Africa.

(iii) There is absence of causality between the investment categories in agriculture and agricultural output in Africa.

Alternative Hypotheses (H_1):

(i) Domestic private investments are the largest source of investments in agriculture in Africa, followed by domestic public investments, foreign public investments, and foreign private investments.

(ii) The categories of investments in agriculture have a significant positive impact on agricultural output in Africa.

(iii) There is unidirectional causality between the investment categories in agriculture and agricultural output in Africa, with causality from the investment categories to agricultural output.

1.6 Significance of the Study

The significance of the study presents the value the research will make to the existing stock of knowledge. The study will contribute to the growth of existing theories in economics by enriching the stock of knowledge through its reliable findings on the assessment of the impact of investments in agriculture on agricultural output in Africa.

In the broad sense, the study will help African nation-states improve their agricultural growth and productivity. It will do so by helping decision makers, such as technocrats or politicians, highlight the incentives and constraints that influence farmers‟ investment decisions, and subsequently, develop an investment policy framework that will be used as a strategic tool to concentrate investment resources on highly productive areas. Foreign investors and managers of donor organisations will also benefit in gauging of the effectiveness of their funding for the development of African agriculture.

In terms of specificity, the significance of the study stems from the idea that increased agricultural productivity in Africa will lead to increased capital formation, technological progress, increased employment, increased income, poverty alleviation, and food and nutrition security.

Developing countries, especially in Africa face serious challenges mobilising the capital to finance the production of manufactures and other industrial activities. Since there is scope for raising productivity in agriculture by means that require investments in capital, it is possible for investments in the agricultural sector to make substantial contribution to the capital requirements for infrastructure and industrial expansion. The long-run productivity of the capital is what leads to technological progress.

Investments in the agricultural sector in Africa will lead to the creation of employment opportunities to absorb the rapidly increasing labour force, as well as minimise the underutilisation of human resources. Investments in the agricultural sector in Africa will also lead to the development of non-agricultural sectors by creating positive externalities, such as the enhancement of the industrial labour force.

Any development strategy that improves productivity in agriculture would increase income, and thus, the purchasing power of the rural populace. This increase in income has a catalytic impact in industrial development. This is because the increase in aggregate demand resulting from the increased income induces investment opportunities, and therefore, stimulates industrial development.

Investments in the agricultural sector in Africa will lead to the resuscitation/expansion of the production of export crops, with a view to increase and further diversify foreign exchange earnings. Expansion of agricultural exports is one of the most promising means of increasing income and augmenting foreign exchange earnings. The diversification of export production can also lessen the vulnerability of mono-export economies to external shocks.

Investments in the agricultural sector in Africa will lead to increased production of agricultural raw materials to support agricultural exports and domestic manufacturing activities, especially in the field of agro-allied industries. Agriculture has the capacity to supply most of the raw materials for industry that otherwise would be imported. This is particularly true for agro-allied industries. By providing these raw materials domestically, not only is scarce foreign exchange saved, but also, regular supply and generation of gainful employment is sustainable.

In terms of food and nutrition security, investments in the agricultural sector in Africa will lead to food supply in adequate quantities and quality in order to keep pace with rising population growth rates and urbanisation. If food supply increases along with population growth, the pressure on food prices will relax, and foreign exchange that would otherwise be used for food imports can be used for other purposes, such as the importation of machine equipment and raw materials for industry.

Empirically, the study will serve as reference material for members of academia and the general public, who may desire to embark on the investigation of assessing the impact of investments in agriculture on agricultural output in Africa.

1.7 Scope of the Study

The 55 nation-states comprising the African Union (AU) were originally considered for this study, but due to data constraints, 19 countries were excluded. Therefore, the scope of the study centres on 36 member-countries of the African Union and covers the period of 1980 - 2018. These member-countries include: Algeria; Benin; Botswana; Burkina Faso; Burundi; Cabo Verde; Cameroun; Central Africa Republic; Congo; Cote d"Ivoire; Democratic Republic of the Congo; Egypt; Eswatini; Ethiopia; Ghana; Kenya; Lesotho; Liberia; Madagascar; Malawi; Mali; Mauritius; Mozambique; Namibia; Niger; Nigeria; Rwanda; Sierra Leone; South Africa; Sudan; Togo; Tunisia; Uganda; Tanzania; Zambia; and Zimbabwe.

1.8 Outline of the Study

Chapter One provides the introduction to the study that includes the statement of the research problem and the research questions the study intends to answer, amongst others. Following Chapter One is Chapter Two, in which a literature review is provided. In Chapter Three, the methodology applied in conducting the empirical study is documented. This documentation describes the model, data, and econometric techniques, amongst others. In Chapter Four, empirical tests on the established hypotheses and research questions posed in this study are performed, after which the accompanying results and analyses are presented. Finally, in Chapter Five, the summary, conclusion, and policy implications for the study are outlined.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Review on Investments in Agriculture

In order to facilitate the process of understanding the contents of this study, it is critical to provide information on the concepts of investments in agriculture.

Generally speaking, investment entails forfeiting something today in order to accumulate assets that generate income or other benefits in the future (FAO, 2012). Investments can also be defined as the addition to the stock of capital in production directed towards increasing the rate of output in the future (Robinson, 1956). Investments therefore, do not represent the stock of capital in an economy, but rather, the additions to that stock of capital intended to increase future output or income; in short, investment is a flow and involves the formation of capital (FAO, 2013).

According to the FAO (2012), agricultural investment or capital comprises of both tangible and intangible assets and is categorized as follows: (i) physical capital (e.g., farm buildings and structures, machinery and equipment, livestock, etc.); (ii) human capital (acquired through education, training, and experience); (iii) intellectual capital (acquired through research and development of agricultural technologies and managerial practices); (iv) natural capital (e.g., land and other natural resources for agricultural activities); (v) social capital (e.g., the institutions, networks, and regulatory bodies that develop, implement, and regulate agricultural policies); and (vi) financial capital (e.g., private savings, commercial credit facilities, government grants, etc.). Financial capital is predominantly the means through which other types of capital are acquired.

In agriculture, a distinction is usually made between investments (capital expenditure) and spending on operating inputs (recurrent expenditure) based on the length of time required to generate or realise a return, or on the number of returns that can be generated over an extended period of time (FAO, 2012). For instance, planting trees is typically considered an investment, because it takes more than a year to generate a return, but the application of fertilizer to a millet crop is not deemed to be an investment, because it generates a return during the current crop cycle. Similarly, the purchase of machinery and equipment, building of farm houses and storage facilities, etc. are considered investments, because they generate several returns over many years, but the payment of utility bills, etc. is regarded as recurrent expenditure, because it generates a return during the current bill period.

The FAO (2012) reports that farmers in Africa make investments on their farms by acquiring farm equipment and machinery, purchasing animals and rearing them to productive age, planting permanent crops, improving farm land, constructing farm buildings and storage facilities, etc. Governments invest in transport and communications infrastructure, irrigation infrastructure, energy systems, education and healthcare, ecosystem services, provision of agricultural credit and input subsidies, farm and nonfarm employment, market institutions, etc. Governments also invest in agricultural research and development (R&D), which generates intellectual capital, an essential input for increasing and sustaining the long-run productivity of agriculture. Foreign private, as well as foreign public investors may support any of the aforementioned categories of investors. They may also have their own investment strategies, such as investing in agricultural technologies and support institutions, depending on established development goals and objectives.

The food and agricultural organisation (FAO) of the United Nations categorises investments in agriculture as domestic private, domestic public, foreign private, and foreign public investments (FAO, 2012). According to the FAO (2012), the majority of domestic private investors are small-scale farmers, and are by far the largest source of investments in agriculture in Africa. Domestic public investors, specifically the central governments, are the next largest source of investments in agriculture, followed by foreign public investors, such as development partners, and lastly, foreign private investors, such as corporations and other private entities.

2.1.1 Domestic Private Investments

Domestic private investments in agriculture refer to capital expenditures made by small-scale farmers, co-operatives, corporations, and other farm businesses on plantation crops, livestock, land development, machinery and equipment, and farm structures (FAO, 2012). As the ultimate goal of any investment is to maximize profit, so also domestic private investors invest in the productivity of agriculture in order to increase output, and hence, income.

According to Mengoub (2018), domestic private investments are sourced from two main funds:
(i) private savings and (ii) credit facilities from financial institutions. Domestic private investors may invest their savings in agricultural initiatives to generate profit and create added value, or they could approach commercial banks to obtain bank loans, subject to agreed-upon conditions. In general, quantifying domestic private investments has its unique challenges, because while lending institutions adhere to record retention policies concerning loan facilities intended for agricultural

purposes, many transactions involving private savings are not captured on the macroeconomic level, and as such, excluded from the estimates of private investment funds intended for agriculture (Mengoub, 2018).

The FAO (2012) and Mengoub (2018) report that in Africa, there is a relatively low level of accessibility to commercial credit. This low level is attributable to two main reasons: (i) the vast majority of domestic private investors lack the collateral to obtain loans; and (ii) the interest rates applied to the loans are so high that it threatens repayment. Mengoub (2018) opined that the high interest rate is partly due to the high credit risk tagged to domestic private investors. Farmers carry a high credit risk because loans granted to them may not always be applied to agricultural initiatives. In other words, like any other economic agent, farmers may obtain credit and use it to finance personal interests. Farmers also carry a high credit risk because agricultural output is subjected to several hazards, such as insufficient rainfall, insect/pest invasion, bacteria/fungal disease, severe fluctuation of input and output prices, etc.

There is a certain risk associated with agricultural investments that deters investors, particularly domestic private investors from investing in agriculture. This investment risk, more technically referred to as "asymmetry or irreversibility of investments," suggests that once investments are made, there are a few other activities for which they can be productively utilised (Nelson, Braden, & Roh, 1989). For instance, investment in land that is suitable to grow only one particular crop becomes irreversible after the land is purchased. Similarly, investments, such as tractors and other farm machinery have few other uses besides agriculture. Also, human and social capital in agriculture may not adopt well to other industries. Contrast this with investments in construction equipment, which can also be utilised in the quarrying industry. Similarly, investments in human and social capital in the field of finance is transferrable to multiple industries including agriculture. Due to the fixity of agricultural assets, domestic private investors are hesitant to invest in land improvements, heavy duty farm equipment, and human and social capital (Nelson, Braden, & Roh, 1989).

On a global level, there is need for an increase in agricultural output by at least 60% over the next four decades in order to meet the rising demand for food and agricultural commodities, caused by population growth and the expansion of industrialization initiatives (OECD, 2013).

With the development initiatives of the African Union"s Comprehensive Africa Agriculture Development Programme (CAADP), supplemented by the development of several indigenous privately owned mega farm businesses across the entire continent, the agricultural output gap in

Africa is bound to close (Somma, 2008). Examples of such farm businesses include: Obasanjo Farms in Ota, Ogun State, Nigeria; Maizube Farms in Minna, Niger State, Nigeria; Songhai Farms in Porto Novo, Republic of Benin; Karsten Farms in Cape Town, South Africa; Makar Farms in Al Badrashin, Egypt; Sentlhane Farms in Mmokolodi Kweneng, Botswana; etc.

According to the FAO (2012), domestic private investment is essential if agriculture is to fulfil its critical role of contributing to economic growth, poverty alleviation, and food security. Thus, an investment policy framework that is transparent, non-discriminatory, and geared towards the growth and sustainable development of private investments in agriculture must be established and adhered to in order to achieve this development objective (OECD, 2013; FAO, 2013). Embedded in this policy framework must be the recognition of the rule of law that emphasizes the enforcement of contracts and equity, good governance, and a sound tax system (OECD, 2013; FAO, 2013). Public investments in basic infrastructure (particularly in the areas of irrigation, transport and storage, energy and information communication technologies - ICT), human capital formation, and agricultural research and development are also essential conditions to create an enabling environment for private investors to maximize the development benefits of investments in agriculture (Antholt, 1994; Evenson & Mckinsey, 1991; Pray & Evenson, 1991; Pardey, Roseboom, & Craig, 1992).

2.1.2 Domestic Public Investments

The FAO (2012) defines domestic public investments in agriculture as capital expenditures made by governments on “public goods,” as well as investments made by governments, which generate benefits for society that cannot be captured by a private investor. A public good is a good that is “non-exclusive” and “non-rival.” In other words, a public good is a good that people cannot be excluded from utilising, and the use by one person does not diminish the ability of others to use it (FAO, 2012). Examples of public goods for agriculture include rural roads, railway systems, electricity, water infrastructure, and other physical infrastructure. Other types of public investments in agriculture include the development of institutions, building of human capacity, research and development, etc.

Public investments in agriculture also include government intervention programmes designed to achieve specific objectives. For instance, in Nigeria, the Operation Feed the Nation (OFN) and Green Revolution programmes established in 1976 and 1980, respectively, were designed to promote the development of the agricultural sector, achieve self-sufficiency in food production, and foster a young farming population (Ode-Omenka, 2018). The Comprehensive Rural Development Programme (CRDP) was established in 2009 in South Africa with the goal of eliminating poverty, reducing inequality, and improving food and nutrition security by the year 2030 (South African Government, n.d.). Ghana established the Northern Rural Growth Programme (NRGP) in 2007 with the aim of substantially increasing the income of rural households in Northern Ghana through agriculture (AfDB, 2017). Botswana in the year 2008 created the Integrated Support Programme for Arable Agricultural Development (ISPAAD) to address the challenges of poor use of technology and low productivity in the agricultural sector (Government of Botswana, n.d.).

Deficiencies in public investments can be an impediment to development. For instance, the ADB (2007) finds that poor infrastructure and the lack of investments in infrastructure restrict growth. On the other hand, spending on public investments, such as roads and irrigation can lead to significant increases in agricultural output (Fan, Hazell, & Thorat, 2000; Fan & Zhang, 2004). Additionally, there is a general consensus in the studies of Antle (1984), Binswanger, Khandker, and Rosenzweig (1989), and Mogues, Yu, Fan, and McBride (2012) that public investments are essential in achieving the dual objective of agricultural growth and poverty alleviation. Research also reveals that public spending on agricultural research and development (R&D) is essential in increasing agricultural productivity and reducing rural poverty (Fan, Gulati, & Thorat, 2008; Fan & Brzeska, 2010; Mogues, 2015).

Governments often use the subsidy instrument in public expenditure policy to increase agricultural output. Though, empirical evidence reveal that spending on subsidies, such as fertilizers have a negative impact on agricultural growth (Gulati & Narayanan, 2003; Mogues et al., 2012), other studies reveal that increases in public expenditure towards subsidies provide incentives for domestic private investments, ultimately resulting in increased agricultural growth (Chirwa & Dorward, 2013; Chand & Pandey, 2008). Nonetheless, it can be inferred that public expenditure on agriculture and rural development induce domestic private investments and agricultural growth (Dhawan, 1996; Gulati & Bathla, 2001; Bathla 2014). Having said this, the impact of public investments is largely dependent on the composition and quality of the expenditure (FAO, 2012; Fan & Chan-Kang, 2005; Fan & Rao, 2008; Fan & Brzeska, 2010; Mogues et al., 2012).

Public investments constitute a critical component of fiscal policy used by governments to influence the level of aggregate demand in the economy, in an effort to achieve economic objectives of price stability, full employment, and economic growth. Thus, the increase in government spending is an expansionary fiscal policy to stimulate the economy. There are instances where government spending can have unfavourable impact on the economy. For example, government spending can cause the private sector to lose out on opportunities to undertake investments in public goods and services. Excessive government spending can also create budget deficits or inflation, especially when government expenditure is financed through borrowing or seigniorage.

2.1.3 Foreign Private Investments

According to the FAO (2012), foreign private investments in agriculture refer to foreign direct investments (FDI). Simply put, FDI is the establishment of an enterprise by a foreigner or foreign company in a country; its definition can be extended to include investments made to acquire lasting interest in enterprises operating outside the economy of the investor (FAO, 2019; UNCTAD, 2019). The FDI relationship often consists of a parent enterprise and a foreign affiliate, which together form a transnational corporation (TNC). In order to qualify as FDI, the investment must afford the parent enterprise *control* over its foreign affiliate. In this case, *control* is defined as owning 10% or more of the ordinary shares or voting power of an incorporated firm or its equivalent for an unincorporated firm; lower ownership shares are referred to as portfolio investments. That is, portfolio investment represents passive holdings of securities, such as foreign stocks, bonds, or other financial assets, none of which entails active management or control of the securities' issuer by the investor; where such control exists, it is referred to as FDI (FAO, 2019; UNCTAD, 2019).

There are two types of FDI: inward foreign direct investment and outward foreign direct investment, both measurable in terms of stocks or flows (FAO, 2019; UNCTAD, 2019). Stock is the total accumulated value of foreign owned assets at a point in time (usually at year-end), while flow is the amount of FDI over a period of time (usually one year). Stocks (or positions) allow a structural analysis of foreign investments in the host (or reporting) economy and investment of the home (or investor) economy in foreign countries. Flows (or transactions) provide an indicator about the attractiveness of the economies (FAO, 2019; UNCTAD, 2019). Thus, inward FDI stock is the value of foreign investors‟ equity in and net loans to enterprises resident in the reporting economy, while outward FDI stock is the value of the resident investors‟ equity in and net loans to enterprises in foreign economies. FDI inflows are the value of inward direct investment made by foreign investors in the reporting economy, while FDI outflows are the value of outward direct investment made by resident investors in the reporting economy to external economies (FAO, 2019; UNCTAD, 2019).

FDI inflows are often regarded as a growing source of finance with major potential for agricultural growth and development (FAO, 2019). Besides being a source of capital, FDI in agriculture is important, because it creates opportunities in terms of employment and technology transfer, as well as supplements domestic private investments (FAO, 2014; Oleyede, 2014). Studies also indicate that FDI can help raise agricultural land and labour productivity through farmer training and education, improved access to farm inputs, utilisation of better farm techniques and improved agricultural technologies (Almfraji & Almsafir, 2014; Görgen, Rudloff, Simons, Üllenberg, Väth, & Wimmer, 2009).

For FDI to make a productive impact in an economy, there must be: (i) an even and competitive playing field without prejudice for domestic and foreign investors; (ii) an enabling environment in which foreign investors can operate (i.e., presence of basic infrastructure, institutional frameworks, rule of law, etc.); (iii) socio-political peace and stability; amongst others (Borenzstein, De Gregorio, & Lee, 1998; Klein, Aaron, & Hadjimichael, 2001; Oleyede, 2014).

In summary, the impact of FDI in agriculture is not always straight forward. For instance, whereas the mineral sector attracts relatively high FDI because of its immediate profits, the agricultural sector may sometimes be relegated by foreign investors because of the time lag associated with agricultural yield. Additionally, the transfer of technology and managerial skills associated with FDI tend to be concentrated in the manufacturing sector more so than the agricultural sector. FDI that involve direct control of resources, such as agricultural land, also make the concept of FDI less desirable to host economies (Findlay, 1978; Wang & Bloomstrom, 1992; UNCTAD, 2001; Alfaro, 2003).

2.1.4 Foreign Public Investments

The FAO (2019) defines foreign public investments in agriculture as cross-border capital flows (mostly in the form of aid) to recipient countries with the promotion of agricultural growth, poverty alleviation, and economic development as the main objectives. Foreign public investments are primarily sourced from: (i) multinational organisations, such as the World Bank, the International Monetary Fund (IMF), the United Nations Development Programme (UNDP), the African Development Bank (AfDB), etc.; (ii) bilateral donors, such as member-countries of the Development Assistance Committee (DAC) of the Organisation for Economic Co-operation and Development (OECD), etc.; and (iii) private foundations, such as the Rockefeller Foundation, the Bill and Melinda Gates Foundation, etc. (FAO, 2019).

The NEPAD (2010) reports that while rich countries (e.g., U.S.A, Canada, Western European countries, etc.) support their agricultural industry with aid, most countries in Africa are poor and behind the development frontier in agriculture, that they depend on rich nations outside the continent for aid to help bridge their agricultural output gap. However, the ability of developing countries to receive foreign aid from bilateral and multilateral institutions is largely dependent on the adoption of trade liberalization policies by the requesting countries; the adoption of such policies has its pros and cons (Edwards, 1993; Remmer, 2004).

Thus, there are two sides to the issue concerning the impact of foreign aid on economic growth. One side argues that aid has a positive impact on the economy, especially in countries with sound economic and trade policies, while the other side argues that foreign aid creates an enabling environment for corruption and dependency. In the case of the former, Burnside and Dollar (1997) find that foreign aid promotes economic growth in as much as sound fiscal policies are in place. Examples of sound fiscal policies include: maintaining small budget deficits; controlling inflation; and being open to international trade. Durbarry, Gemmell, and Greenaway (1998) also find a positive relationship between foreign aid and economic growth, as well as confirm Burnside and Dollar"s (1997) findings of the significance of good economic policies. Ali and Isse (2005) further confirm the findings of Burnside and Dollar (1997), but note that aid is subjected to decreasing marginal returns, thus, highlighting the long run detrimental impact of aid on economic growth.

In the case of the latter, a study by Boone (1995) reveals that aid-intensive African countries experienced zero per capita economic growth in the 1970s and 1980s, despite increases in foreign aid. Boone (1995) concludes that aid does not significantly increase investments and growth, but rather, increases the size of government. Whitaker (2006) questions the actual effectiveness of aid given to less developed countries (LDCs), comparing the amounts disbursed to the growth derived. In addition, Knack (2000) and Moyo (2010) find that high levels of foreign aid can reduce institutional efficiency, foster corruption, and encourage dependency. On the extreme end, Bauer (1971) and Friedman (1958) heavily criticize foreign aid on the premise that politicians inhibit the efficient allocation of aid against the objectives of the programmes.

Evidence also suggest that non-economic factors, such as ethno-religious conflicts, political instability, etc., can potentially influence the extent to which foreign aid affects growth (Bauer, 1971; Friedman, 1958). In summary, because of the double-edged sword that foreign aid is, there is no consensus among economic scholars as to the actual impact of foreign aid on economic growth, and agricultural output for that matter.

2.2 Theoretical Review on Investments in Agriculture

This section reviews the economic theories that relate to the impact of investments in agriculture on agricultural output.

2.2.1 The Malthusian Theory of Population

English economist of the classical era, Malthus (1798), posited in his "theory of population" that an increase in a nation‟s food production improved the overall well-being of the populace. In so doing, Malthus highlights the significance of the growth of agricultural output in an economy. Indirectly, he also highlights the importance of food security in an economy. This is evident with his support of taxes on grain imports (i.e., the protectionist Corn Laws from the end of the Napoleonic wars) under the premise that food security is more important than wealth maximization. Malthus also postulated that population increases in a geometric progression (i.e., 2, 4, 8, 16, 32, 64, 128, …., etc.), whereas food production increases in arithmetic progression (i.e., 2, 4, 6, 8, 10, 12, 14, …., etc.). Thus, population increases at a faster rate than food production. According to Malthus, unless reproduction is voluntarily reduced through self-restraint ("preventive checks"), population would be reduced by cataclysmic events such as famine, pestilence, and strife ("positive checks") in order to balance food production with population growth.

Malthus‟ views had a profound impact on the thoughts of economic scholars, such as David Ricardo (1772 - 1823), John Stuart Mill (1806 - 1873), and other classical economists. Ricardo and Mill, in particular, both accepted Malthus‟ theory of population, but believed that free trade would generate high profits long enough to relax the pressure on scarce food resources. Malthus claimed that with a fixed amount of land and a growing population, diminishing marginal productivity would result in individuals living continually at a subsistence level. A general critique was that he ignored the possibility that capital accumulation and technological progress could be driving forces to reduce the population pressure, and hence, improve the condition of individuals, despite the reality of a growing population.

Boserup (1965) suggested that Malthus‟ arguments with respect to population growth and agricultural production capacity displayed a "reverse causation." In her perspective, population growth is an independent factor that affects agricultural productivity rather than vice versa. That is, Malthus‟ assumption of diminishing returns to labor will not hold in the long run, as higher population most likely will lead to more efficient division of labor, and hence, improved agricultural labour input. She posited that soil fertility is not a fixed factor as given by nature, but rather, a factor that can be improved on with the influence of agricultural technology, which is likely to be a result of an increase in population (human capital). In short, she concluded that underdeveloped communities with higher population growth rates are more likely to experience economic development, provided the necessary investments in agriculture are undertaken.

Simon (1977) is another critique of the Malthusian thought, emphasizing the long run benefits of population growth and agricultural production. According to Simon, whereas in the short run, population growth has a negative effect on living standards due to diminishing returns and the temporary burden it poses on society because of scarce food resources, in the long run, it has positive effects on living standards and agricultural productivity due to knowledge advancement and economies of scale.

Galor and Weil (2000) also express a contrarian view to that of Malthus with respect to population growth and agricultural production capacity. They posit that population growth induces investments in human capital, which gradually improves technology, resulting in improved quantity and quality of agricultural output, per capita income, and living standards.

Theorising before the industrial revolution, Malthus could not have foreseen the impact of technology in agriculture in modern times, with respect to mechanized farm equipment, irrigation intelligence, storage facilities (like silos and refrigerators), agricultural security infrastructure (like drones), pesticides, high yielding seeds and fertilizers, biotechnology, etc. Thus, food production can indeed grow geometrically, because production depends not only on land, labour, and capital, but also on technological progress. Notwithstanding, the Malthusian era is regarded as a necessary stage in order to achieve increased agricultural output and sustained economic growth.

2.2.2 The Neoclassical and Endogenous Growth Theories

The neoclassical and endogenous growth theories explain the influence of technological progress in production. The neoclassical growth theory credits technological progress as the engine of economic growth. The theory assumes that capital accumulation is capable only of driving productivity in the short run, as it suffers from diminishing marginal returns in the long run. Thus, productivity growth in the long run is mainly attributable to exogenous technological progress, which explains the rate of growth of output over time (Zipfel, 2004).

The endogenous growth theory on the other hand assumes that capital accumulation is indeed capable of driving productivity both in the short and long run. The theory refrains from treating technological progress as exogenous, but rather, as an endogenous concept that results from the decisions of economic agents or economic forces. In other words, the assumption is that technological progress results from the allocation of resources to create new ideas that lead to the improvement of technology, effective and efficient means of production, and hence, the growth of output. These new ideas are generated from investments in human capital (Romer, 2001).

While physical capital is regarded as a key contributing factor to agricultural productivity, economic studies have identified human capital to be a critical and productive component of investments in agriculture, as well as a complimentary input to physical capital in agricultural production (Ndour, 2017; Mehdi, 2011; Lanzona, 2013; Kifordu, 2015). Human capital refers to “knowledge” acquired through education, training, and experience. Human capital affects agricultural productivity by improving the way inputs are utilised and combined. It may also be embedded in the inputs that go in to the production process. More importantly, human capital influences the creation, application, and transformation of technology. In short, in order to examine the relationship between investments in agriculture and agricultural output, agricultural investments must include human capital (Griliches, 1963; Jamison & Lau, 1982).

2.2.3 The Cobb-Douglas Production Theory

Within the context of growth in output, the neoclassical and endogenous growth theories succeed the Malthusian theory of population. In modelling the output performance of the economy, the neoclassical growth theoreticians (e.g., Solow, 1956; Meade, 1951, 1955; etc.) and endogenous growth theoreticians (e.g., Romer, 1986; Lucas, 1988; etc.) utilise the classic Cobb-Douglas production theory (1928). In other words, the neoclassical and endogenous growth functions are derived from the Cobb-Douglas production function. Propounded by Cobb and Douglas (1928), the Cobb-Douglas production function illustrates a technical relationship between inputs and outputs of any sector, be it agriculture or industry. The Cobb-Douglas production function operates under two key assumptions. First, it assumes two factor inputs in production, labour and capital. Second, it assumes unitary or constant elasticity of substitution between the two factor inputs. In other words, the sum of the elasticities of output with respect to labour and capital inputs will at all times be equal to one, implying that the production function exhibits constant returns to scale.

2.3 Empirical Review on Investments in Agriculture

In the empirical literature, there are several studies that investigate the impact of investments in agriculture on agricultural output in the case of individual countries, as well as a group of countries. However, conflicting results due to variations in the era studied, country or group of countries focused on, or the estimation methods used, still make this subject matter current and a focal point.

Ogwumike and Ozughalu (2014) examined institutional reforms, credit incentives, and agricultural sector performance in Nigeria with secondary annual time series data covering 1960 – 2012. Applying the Johansen cointegration test, the results reveal a long run equilibrium relationship between the variables used in the study. Using the error correction model, the parameter estimates associated with the agricultural sector credit and institutional reform variables were found to be statistically insignificant, thus implying that investments in credit incentives and institutional reform do not have significant impact on agricultural sector performance in Nigeria. The reason is because agriculturalists in Nigeria do not respond favourably to credit incentives and the corruption embedded in Nigerian institutions stunts progressive development.

Wang and Huang (2018) examined the impact of agricultural science and technology inputs on agricultural economic growth. Secondary annual (balanced) panel data constituting 30 provincial administrative units of China from 2006 to 2017 was used for the study. Utilising the pooled OLS estimation technique, the findings reveal that investments in agricultural technology inputs contribute significantly to agricultural economic growth.

Ighodaro (2011) examined the nexus between infrastructure and agricultural growth in Nigeria with secondary annual time series data from 1960 – 2004. Applying the Johansen cointegration test, the results reveal a long run equilibrium relationship between the variables used in the study. Using the Error Correction Model, the findings are that the error correction coefficient is statistically significant with the expected negative sign; thus, suggesting a high speed of adjustment to long run equilibrium. The findings also confirm the validity of a significant impact of investments in infrastructure on agricultural growth in Nigeria. However, the researcher notes that sectorial-specific effects of the various forms of infrastructure should be taken in to consideration in the design of policies to promote agricultural growth in Nigeria.

Baba, Saini, Sharma, and Thakur (2010) analysed the impact of public and private investments on agricultural growth and rural development in Himachal Pradesh, India. The study involved secondary annual time series data for three sub-periods: 1969 to 1979; 1980 to 1990; and 1991 to 2001. To overcome the limitations of simultaneous bias of single equation models, and to capture and quantify the direct, as well as the indirect effect of fiscal measures in agricultural growth and poverty reduction, a simultaneous equation model with the Two Stage Least Squares (2SLS) estimation procedure was employed to conduct the study. The key findings are that: (i) the improvement of public investment in agriculture will not only augment the level of capital, but also, induce private investment in the agricultural sector; and (ii) agricultural investment is instrumental in the development of rural areas, not only directly by alleviating poverty, but also indirectly by improving agricultural productivity and increasing non-farm employment.

Bathla (2017) conducted a study evaluating the impact of public investments on agricultural growth in India, using secondary annual panel data for seventeen major states covering 1981 to 2013. Applying the pooled OLS and dynamic panel estimation techniques, the analysis reveals that low and inadequate public capital formation during the 1990s negatively impacted farmers‟ investments, and jeopardized technological change and agricultural growth. A big push in resource allocation towards agriculture and irrigation from the early 2000s was in order, however, capital deepening for higher agricultural productivity and income is highly recommended going forward.

Epaphra and Mwakalasya (2017) analysed the impact of foreign direct investment (FDI) on the agricultural sector and economic growth of Tanzania. Secondary annual time series data covering 1990 to 2015 and the ordinary least squares method of estimation were employed for the study. The key findings are that there is no significant effect of FDI inflows on agriculture despite the heavy presence of FDI inflows in the economy. However, FDI inflows and real GDP growth rate are positively correlated. The main reason is because FDI interests in the country has shifted from agriculture to the mining and quarrying and manufacturing sectors. Additionally, the low performance, small-scale, and weak institutional arrangements of the agricultural sector do not make it a viable option for joint ventures with foreign investors.

Sinha (2017) examined the contribution of investments in the economic growth of major sectors in Bihar, India, with emphasis on the agricultural and allied sectors. Using secondary annual time series data spanning from 1980 to 2015, and the Ordinary Least Squares (OLS) estimation technique, the study reveals that augmenting public investments in the agriculture and allied sectors lead to increases in sectorial, as well as aggregate growth rate of GDP. The findings also reveal a strong influence of the agriculture and allied sectors on manufacturing and service sectors.

Bathla (2014) conducted a state level analysis of public and private capital formation and agricultural growth in India during Pre- and Post-reform Periods. The study was conducted using the fixed and random effects models, and secondary annual panel data for eighteen states covering two sub-periods (1980 to 1991 and 1999 to 2006). The key findings are that: (i) private investment in agriculture is driven by public spending on agricultural infrastructure, institutional credit, and the demand for agricultural raw materials by the agro-allied industry, whereas, public investment is largely driven by the size of government spending and the need to sustain agricultural drives; and (ii) agricultural investments positively impact agricultural income, causing a decline in rural poverty.

Bathla, Joshi, and Kumar (2017) examined temporal and spatial trends in public and private investments in agriculture in India, and their impact in terms of agricultural growth and mitigation of rural poverty. The study used secondary annual panel data spanning from 1981 to 2014. In order to quantify the multivariate complex system of the study, structural equation modelling (SEM) was used. The findings are that private investment in minor irrigation and public investment in agriculture research and development, education, rural development, and energy, raise agricultural income and alleviate rural poverty.

Haji-Rahimi (2012) examined investments in technical progress as a major factor in stimulating agricultural growth in Iran. The study employed secondary annual time series data covering 1971 – 2005, and structural equation modelling (SEM). The key findings are that the driving forces of technical progress are global spillover and human capital, but investments in physical capital and material inputs have the most significant role in growing the agricultural sector.

Manjunath and Kannan (2017) examined the effects of rural infrastructure on agricultural development in Karnataka, India, using secondary annual panel data compiled on 19 districts over the period of 1980 to 2009. Using the pooled OLS and random effects models, the findings are that investments in rural infrastructure have a significant impact on agricultural productivity growth, with the potential to grow the economy through spillover effects.

Mustapha and Enilolobo (2019) analysed the effect of public agriculture spending on agricultural output in Sub-Saharan Africa (SSA) using secondary annual pooled data compiled on 18 SSA countries from 2001 - 2017. Employing the generalized method of moments (GMM) estimation technique, the findings reveal that public spending, particularly in the areas of research and development and public infrastructures like energy and rail line, enhance agricultural sector performance.

Barkat and Alsamara (2019) examined the impact of foreign agricultural aid and total foreign aid on agricultural output in Africa using secondary annual panel data compiled on 29 African countries from 1975 – 2013. Employing the Augmented Mean Group and the Common Correlated Effects-2SLS estimation techniques, the findings indicate a small, but significant positive impact of foreign agricultural aid and total foreign aid on agricultural output.

Alabi (2014) examined the impact of agricultural foreign aid on agricultural growth in Sub-Saharan Africa (SSA) using secondary annual pooled data compiled on 47 SSA countries from 2002 – 2010. Employing the generalized method of moments (GMM) estimation technique, the findings reveal that inflows of foreign agricultural aid has a positive and significant impact on agricultural GDP and agricultural productivity.

Llanto (2012) examined the impact of infrastructure on agricultural productivity in the Philippines using secondary annual panel data compiled on 9 regions from 1990 to 2007. Utilising the random effects GLS estimation technique, the findings reveal that investments in rural infrastructure, particularly electricity and roads, like other public investments, raise agricultural productivity, induce growth in rural areas, and in so doing, reduce poverty levels. This is because access to electricity creates various income earning opportunities for rural households, and rural roads network lessens input and transaction costs of rural producers and consumers.

In discussing the effects of infrastructure on agricultural productivity in developing countries, there is a general consensus in the studies of: Antle (1984); Binswanger, Khandker, and Rosenzweig (1989); Zhang and Fan (2004); Mundlak, Larson, and Butzer (2002); Craig, Pardey, and Roseboom (1997); Evenson and Quizon (1991); Teruel and Kuroda (2004); Manalili and Gonzales (2009); amongst others, that investments in infrastructure, particularly in the areas of roads network, electricity, and irrigation systems are essential in the growth of the agricultural sector and the economy at large (Llanto, 2012).

Table 1 provides a summary of the empirical review on investments in agriculture.

Table 1 Summary of Empirical Review on Investments in Agriculture.

Author(s)	**Area of Investment**	**Region**	**Type of Data**	**Period**	**Estimation Technique**	**Positive and Significant Impact on Agricultural Sector Performance**
Baba, Saini, Sharma, and Thakur (2010)	Public and Private	Himachal Pradesh, India	Secondary annual time series	Three sub-periods: 1969 – 1979; 1980 – 1990; and 1991 – 2001	Simultaneous equation model; two Stage least squares (2SLS)	Yes
Ighodaro (2011)	Infrastructure	Nigeria	Secondary annual time series	1960 – 2004	Johansen cointegration test and error correction model	Yes
Haji-Rahimi (2012)	Technical Progress	Iran	Secondary annual time series	1971 – 2005	Structural equation modelling	Yes
Llanto (2012)	Infrastructure	9 regions in the Philippines	Secondary annual panel	1990 – 2007	Random effects GLS	Yes
Alabi (2014)	Agricultural foreign aid	47 countries in Sub-Saharan Africa (SSA)	Secondary annual pooled data	2002 – 2010	Generalized method of moments	Yes
Bathla (2014)	Public and private capital Formation	Eighteen states in India	Secondary annual panel	Two sub-periods: 1980 – 1991 and 1999 – 2006	Fixed and random effects	Yes
Ogwumike and Ozughalu (2014)	Institutional reforms and Credit Incentives	Nigeria	Secondary annual time series	1960 – 2012	Johansen cointegration test and error correction model (ECM)	No

Bathla (2017)	Public	Seventeen major states in India	Secondary annual panel	1981 – 2013	Pooled OLS and dynamic panel	Yes
Bathla, Joshi, and Kumar (2017)	Public and Private	India	Secondary annual panel	1981 – 2014	Structural equation modelling (SEM)	Yes
Epaphra and Mwakalasya (2017)	Foreign direct Investment (FDI)	Tanzania	Secondary annual time series	1990 – 2015	Ordinary least squares (OLS)	No
Manjunath and Kannan (2017)	Rural infrastructure	Nineteen districts in Karnataka, India	Secondary annual panel data	1980 – 2009	Pooled OLS and random effects	Yes
Sinha (2017)	Public	Bihar, India	Secondary annual time series	1980 – 2015	Ordinary least squares	Yes
Wang and Huang (2018)	Agricultural science and Technology Inputs	30 provincial administrative units of China	Secondary annual (balanced) panel	2006 – 2017	Pooled OLS	Yes
Barkat and Alsamara (2019)	Foreign Agricultural aid and total foreign aid	Twenty-nine countries in Africa	Secondary annual panel	1975 – 2013	Augmented mean group and common correlated effects-2SLS	Yes
Mustapha and Enilolobo (2019)	Public Agriculture Spending	Eighteen countries in Sub-Saharan Africa (SSA)	Secondary annual pooled	2001 - 2017	Generalized method of moments (GMM)	Yes
General consensus in the studies of: Antle (1984); Binswanger, Khandker, and Rosenzweig (1989); Evenson andQuizon (1991); Craig, Pardey, and Roseboom (1997); Mundlak, Larson, and Butzer (2002); Teruel and Kuroda (2004); Zhang and Fan (2004); Manalili and Gonzales (2009); amongst others, that investments in infrastructure, particularly in the areas of roads network, electricity, and irrigation systems are essential in the growth of the agricultural sector and the economy at large (Llanto, 2012).						

Source: Author's Compilation.

Despite the differences in research objectives, temporal and spatial coverage, and methodology, the reviewed empirical studies generally support the hypothesis of a favourable impact of investments in agriculture on agricultural output.

Some of the reviewed empirical studies provide estimates and analyses on how much investments are needed, and in what areas e.g., institutional reform and credit incentives (Ogwumike & Ozughalu, 2014), technical progress (Wang & Huang, 2018; Haji-Rahimi, 2012), and infrastructure (Ighodaro, 2011; Manjunath & Kannan, 2017; Llanto, 2012; Antle, 1984; Binswanger, Khandker, & Rosenzweig, 1989; Zhang & Fan, 2004; Mundlak, Larson, & Butzer, 2002; Craig, Pardey, & Roseboom, 1997; Evenson & Quizon, 1991; Teruel & Kuroda, 2004; Manalili & Gonzales, 2009). Other empirical studies focused on who the investors should be, and in what capacity e.g., private and public (Baba, Saini, Sharma, & Thakur, 2010; Bathla, 2014), public (Bathla, 2017; Sinha, 2017; Bathla, Joshi, & Kumar, 2017; Mustapha & Enilolobo, 2019), foreign private (Epaphra & Mwakalasya, 2017), or foreign public investors (Alabi, 2014; Barkat & Alsamara, 2019).

However, none of the empirical studies reviewed conducted a comprehensive analysis of the impact the four categories of investments/investors in agriculture have on agricultural output in Africa. The researcher is also not aware of any study undertaking such analysis. This study therefore aims to address this empirical gap.

CHAPTER THREE

METHODOLOGY

3.1 Research Design

The research design for this study is Ex post factor research. The study utilises both descriptive and inferential statistics for data analysis. Descriptive statistics are measures of central tendency and measures of variability (spread) that summarise the features of a given data set (Gujarati, 2003). Measures of central tendency include the mean, median, and mode, while measures of variability include the standard deviation, variance, minimum and maximum variables, and skewness and kurtosis (Gujarati, 2003).

Inferential statistics on the other hand are used to make predictions and inferences about a given population based on sample data taken from the population in question (Gujarati, 2003). In making predictions and inferences with respect to the data obtained for this study, a set of hypotheses concerning the relationship between investments in agriculture and agricultural output was first established. Secondly, an econometric model was developed to test the hypotheses. Thirdly, the parameter values (or estimates) that give empirical content to the econometric model were obtained using the statistical technique of regression analysis. Fourth, the test of hypotheses was conducted and the research questions posed in the study answered. Lastly, from the detailed analyses of empirical results, the findings of the study, along with conclusive remarks and policy implications based on the observed results were reported.

3.2 Theoretical Framework

This study utilises the Cobb-Douglas production theory (1928) as its theoretical framework. Cobb-Douglas (1928) postulate that the level of output is determined by two key inputs, labour and capital, augmented by an exogenous technical factor. The Cobb-Douglas production function is expressed as follows:

$$Y_t = f([A_t L_t^{\beta}] K_t^{1 - \beta})$$

Where:

Y_t = Total output

A_t = Labour-augmenting technology or "knowledge"

$A_t L_t$ = Effective labour

K_t = Capital stock

β and 1 – β = Elasticities of total output with respect to labour, L and capital stock, K

0 < β < 1 and t denotes time

3.3 Model Specification

Drawing from the objectives of this study and the theoretical framework provided, the agricultural output function for the empirical analyses in this study is specified as follows:

$$Y_t = f([A_t L_t^{\beta}] K_t^{1 - \beta}) \qquad (1)$$

$$Y_t = f([A_t L_t^{\beta 1}] K_t^{\beta 2}) \qquad (2)$$

Where:

$\beta_1 = \beta$ and $\beta_2 = 1 - \beta$

$$AOI_{it} = f(DPRI_{it}^{\beta 1}, DPGE_{it}^{\beta 2}, DPRD_{it}^{\beta 3}, FPRI_{it}^{\beta 4}, FPUI_{it}^{\beta 5}) \qquad (3)$$

Where:

AOI_{it} = Agricultural Output, proxied by agricultural output index $DPRI_{it}$ = Domestic Private Investments

$DPGE_{it}$ = Domestic Public Investments in terms of General Government Expenditure on

Agriculture

$DPRD_{it}$ = Domestic Public Investments in terms of Public Spending on Agricultural Research and Development {R&D}

$FPRI_{it}$ = Foreign Private Investments

$FPUI_{it}$ = Foreign Public Investments

$\beta_1 \ldots \beta_5$ = Elasticities of agricultural output with respect to the different classes of investments

Comparing the Cobb-Douglas production function (2), to the agricultural output function (3), total output (Y_t) in (2) is represented by agricultural output index (AOI_{it}) in (3). Capital stock (K_t), labour-augmenting technology or “knowledge” (A_t), and effective labour ($A_t L_t$) in (2) are incorporated in to the different investment variables constituting (3) (FAO, 2019). For instance, K_t is the value of physical capital (machinery, buildings, etc.) plus the value of materials (chemical fertilizers, pesticides, seeds, etc.) included in the DPRI, DPGE, DPRD, FPRI, and FPUI variables. A_t is the value of technological progress included in the DPRD variable, which is also included in the other variables. For instance, FPUI includes funds from international donors to sponsor biodiversity programmes (e.g., biotechnology, bioengineering, etc.). $A_t L_t$ is the value of investments in agricultural labour employed in the sector that is included in the DPRI, DPGE, DPRD, FPRI, and FPUI variables.

With respect to the factors of production, land is the only factor input not explicitly included in the Cobb-Douglas production function (2). For instance, the other factors, labour, capital, and enterprise are represented by the L_t, K_t, and A_t variables, respectively. Having said this, the land factor is incorporated in to the investment variables constituting the agricultural output function (3), as investments in land development (FAO, 2019).

To rule out the difference in unit of measurement of the variables, (3) is converted to a double-log regression model by taking the natural log on both sides. With this conversion, the potential issue of heteroscedasticity is suppressed. Additionally, agricultural output elasticity with respect to the regressors can be directly obtained. The result of the conversion is as follows:

$$\ln AOI_{it} = \beta_0 + \beta_1 \ln DPRI_{it} + \beta_2 \ln DPGE_{it} + \beta_3 \ln DPRD_{it} + \beta_4 \ln FPRI_{it} + \beta_5 \ln FPUI_{it} + \varepsilon_{it} \quad \ldots\ldots (4)$$

Where:

$\beta_0 \ldots \beta_5$ = Parameters to be estimated

β_0 = Intercept

$\beta_1 \ldots \beta_5$ = Slope

ε_{it} = Error term

Given the nature of this study, it is prudent to add **key** control variables, such as credit to agriculture, agricultural policy, exchange rate, and trade openness (or liberalization) to the specified model (4). A priori, these **control** variables are also likely to impact agricultural output, alongside the **focus** variables, DPRI, DPGE, DPRD, FPRI, and FPUI. In other words, it is possible that agricultural output may vary as there are changes in the levels of the exchange rate and credit disbursed to agriculture. Likewise, agricultural output may vary as the economy becomes increasingly open to trade, or adopts more trade liberalisation policies. Agricultural output is also likely to respond to changes in agricultural policies. Other likely control variables are captured by the random error term. Multicollinearity is also suppressed by including only these key control variables. Based on these analyses, the multiple linear regression model is modified as follows:

$$\ln AOI_{it} = \beta_0 + \beta_1 \ln DPRI_{it} + \beta_2 \ln DPGE_{it} + \beta_3 \ln DPRD_{it} + \beta_4 \ln FPRI_{it} + \beta_5 \ln FPUI_{it} + \beta_6 \ln CRA_{it} + \beta_7 \ln AP_{it} + \beta_8 \ln EXRT_{it} + \beta_9 \ln TROP_{it} + \varepsilon_{it} \quad \ldots\ldots (5)$$

Where:

CRA_{it} = Credit to Agriculture

AP_{it} = Agricultural Policy

$EXRT_{it}$ = Exchange Rate

$TROP_{it}$ = Trade Openness

$\beta_0 \ldots \beta_9$ = Parameters to be estimated

$\beta_1 \ldots \beta_9$ = Slope

$\beta_1 \ldots. \beta_9$ = Elasticities of agricultural output with respect to the focus and control variables

3.3.1 A priori Expectations

The rationale for including the different variables in the specified model (5), as well as the expectations of the model are based on existing theoretical literature and prior knowledge. These expectations may vary from one variable to another; that is, some independent variables may exhibit a positive impact on the dependent variable, while others may indicate a negative impact. The **Constant** of the model, β_0 is expected to be positive (i.e., $\beta_0 > 0$) given Africa's enormous natural and human resources, which have the capacity to influence output in the agricultural sector holding all other variables as specified in the model constant.

DPRI, DPGE, DPRD, FPRI, and FPUI

As discussed earlier, investments by being a component of national income will augment GDP. Similarly, investments in agriculture will augment agricultural output, since agricultural output is a component of GDP. Furthermore, if the postulation is that investments in agriculture promote agricultural output, then this augmentation should be positive in nature. Thus, the coefficients of the DPRI, DPGE, DPRD, FPRI, and FPUI variables measuring the impact of investments in agriculture on agricultural output are expected to be positive. i.e., β_1, β_2, β_3, β_4, and $\beta_5 > 0$.

CRA

The higher the amount of loanable funds available to the stakeholders in the agricultural sector, the greater is the impact on agricultural output. Thus, credit to agriculture is expected to be positively correlated with agricultural output. Based on this direct positive relationship, the coefficient of the CRA variable measuring the impact of credit to agriculture on agricultural output is expected to have a positive sign. i.e., $\beta_6 > 0$.

AP

Agricultural policies such as the award of grants, subsidisation of inputs, tax cuts on agricultural inputs, construction of dams and irrigation structures, flood and soil erosion control projects, construction of roads infrastructure increasing connectivity of villages and towns to nearby cities, and investments in energy infrastructure, etc., increase the productivity of stakeholder investments in agriculture. Also, policies such as the increase in agricultural labour wages, investments in modern inputs and other technologies, as well as investments in agricultural research and development (R&D) increase agricultural productivity. Therefore, it is not farfetched to state that agricultural policy has a direct positive relationship with agricultural output. Based on this analysis, the coefficient of the AP variable measuring the impact of agricultural policy on agricultural output is expected to have a positive sign. i.e., $\beta_7 > 0$.

EXRT

Exchange rate dynamics (i.e., appreciation and depreciation) have ambiguous effects on agricultural output in Africa. Low exchange rates (i.e., depreciation or devaluation of the national currency) induce foreign investments, leading to higher agricultural output levels, but on the other hand, low exchange rates reduce stakeholder capacity to invest in the imports of agricultural inputs, thereby leading to reduced output levels. High exchange rates (i.e., appreciation or upward adjustment of the national currency) suppress foreign investments, leading to reduced output levels, but on the flip side, high exchange rates increase stakeholder capacity to invest in the imports of agricultural inputs, thus leading to higher output levels. Based on the divergent relationship between exchange rate and agricultural output, the coefficient of the EXRT variable measuring the impact of exchange rate on agricultural output is expected to have a negative sign. i.e., $\beta_8 < 0$.

TROP

Because trade liberalisation attracts foreign investors, as well as increases the demand for and returns to factors, trade openness is assumed to be positively correlated with agricultural output. Based on this direct positive relationship, the coefficient of the TROP variable measuring the impact of trade openness on agricultural output is expected to have a positive sign. i.e., $\beta_9 > 0$.

Sum of Elasticities

Recall that, the Cobb-Douglas production function assumes unitary or constant elasticity of substitution between the two factor inputs. Thus, the sum of the elasticities of output with respect to labour and capital inputs will at all times be equal to one, implying that the production function exhibits constant returns to scale. i.e., $\beta + (1 - \beta) = 1$. However, such a scenario is rare in reality, as most output functions in agriculture and industry have non-unitary or non-constant elasticity of substitution between the factor inputs (Douglas, 1976; Gechert, Havranek, Irsova, & Kolcunova, 2019). As such, the sum of the elasticities of output with respect to the factor inputs is usually greater or less than one, implying that the output function usually exhibits increasing or decreasing returns to scale, respectively. Based on this analysis, the sum of $\beta_1 \ldots\ldots \beta_9$ of the agricultural output model (5), is expected to $\neq 1$.

3.4 Estimation Techniques

Since this study entails continental analysis of agricultural output that involves 36 countries in Africa over 39 years, panel data estimation techniques will be applied (Gujarati, 2003). This suffices since: (i) the number of cross sectional observations is not substantially higher than the number of time periods (i.e., large N and small t), in which case, the General Method of Moments (GMM) estimation technique would be optimal; and (ii) the number of time periods does not substantially exceed the number of cross sections (i.e., large t and small N), in which case, first differencing of the data and appealing to the central limit theorem (CLT) should mitigate (Wooldridge, 2012). The panel data estimators employed are the Pooled Ordinary Least Squares (Pooled OLS), Fixed-Effects (FE), and Random-Effects (RE) estimators. For optimality, panel model diagnostics and the Breusch-Pagan LM test will be evaluated to compare the Pooled OLS estimator to the FE and RE estimators, while the Hausman specification test will be conducted to choose between the FE and RE estimators.

The Hausman test is designed to assist in choosing between the FE model (FEM) and the RE model (REM) (Gujarati, 2003). The null hypothesis underlying this test is that the *efficient* estimators produced by the REM are not substantially different from the *consistent* estimators produced by the FEM. That is, the Hausman test checks a more efficient model against a less efficient, but consistent model to make sure that the more efficient model also gives consistent results (Gujarati, 2003). The test is based on a measure, the chi-squared (χ^2) statistic that has an *asymptotic* chi-squared distribution, and measures the distance between the REM and FEM estimators. If the estimators are about the same (i.e., the p-value produced by the test is significant), then the null hypothesis is rejected that the random effects model is consistent. In this instance, the FEM is preferred. If on the other hand, the opposite is the case (i.e., the p-value produced by the test is not significant), then the null hypothesis is not rejected, and the REM is preferred (Gujarati, 2003).

The estimation techniques discussed above will be applied to address the second objective of the study. With respect to addressing the first and third objectives, diagrammatic techniques and the pairwise Granger causality test will be applied, respectively.

The statistical software package (i.e., computer software programme) that will be used for this study is Gretl (2020b). The study also utilises the ubiquitous software programme, Microsoft Excel (2013).

3.5 Data Description

The documentation below provides the description of and measure for each variable constituting the augmented regression model. It also provides the justification for the variables employed.

3.5.1 Measure for Agricultural Output

Since it is not pragmatic to add all goods and services together, because of differences in dimension, the summation of all agricultural goods and services produced in a country has to be based either on market price in the same currency dimension, or on indexing system that utilises percentage changes in the physical output of all products relative to a given base year. The issue however with market price valuation, is that they are affected by inflation rates, especially in developing countries that record rapid, and usually double-digit inflation rates. Agricultural GDP at market or current price for instance, is adjusted for inflation rates (real or constant price) through deflation. Since this process is based on estimates of inflation rates, it will be subjected to a wide margin of statistical estimation errors, as well as calculation errors. Thus, an indexing system such as the **agricultural output index**, which selects major industries for production analysis may be more reliable in assessing agricultural output in an economy.

The agricultural output index is compiled by the Food and Agricultural Organisation of the United Nations (FAO, 2019). It shows the relative level of the aggregate volume of agricultural production for each year in comparison with a base period. As of the time of this study, the base period is years 2004 - 2006 for all countries (FAO, 2019). The index is based on the sum of price-weighted quantities of different agricultural commodities produced after deductions of quantities used as seed and feed weighted in the same manner (FAO, 2019). Since the FAO index is based on the concept of agriculture as a single enterprise, amounts of seed and feed (e.g., milk, hatching eggs, etc.) are deducted from the production data in order to avoid double-counting them, once in the production data, and once with the crops or livestock produced from them (FAO, 2019).

There are other deductions that make the resulting aggregate more computationally accurate and representative of a true value of agricultural production. For instance, in terms of indices of agricultural food and non-food production, all intermediate primary inputs of agricultural origin are deducted. However, for indices of any other commodity group, only inputs originating from within the same group are deducted; therefore, only seed is removed from the group “crops” and from all crop sub-groups, and feed is removed from the group “livestock products” (FAO, 2019). Practically all products are covered, with the main exception of fodder crops (i.e., crops that are cultivated primarily for animal feed, e.g., grass) (FAO, 2019). The category of food production includes commodities that are considered edible and that contain nutrients. Thus, coffee and tea are excluded along with inedible commodities, because although edible, have basically no nutritive value (FAO, 2019).

All the indices used to derive the final index at the country, regional, and world levels are calculated using the Laspeyres formula. That is, production quantities of each commodity are weighted by 2004 - 2006 average international commodity prices and summed for each year. Thus, to obtain the final index, the aggregate for a given year is divided by the average aggregate for the base period 2004 - 2006 (FAO, 2019). The international commodity prices are used in order to factor in the exchange rate and purchasing power parity differences at the national level. These international prices are expressed in "international dollars," derived from the Geary-Khamis approach (FAO, 2019).

The commodities covered in the computation of the indices of agricultural production are all crops and livestock products originating from each country; they do not include fishery and forest resources (FAO, 2019). The indices are computed from production data presented on a calendar year basis (FAO, 2019). The FAO indices may also differ from those produced by the individual countries, because of differences in concepts of production, coverage, weights, data period, and methods of computation (FAO, 2019).

3.5.2 Measure for Domestic Private Investments

Domestic private investments in agriculture in Africa are predominantly from small-scale farmers (FAO, 2019). The most comprehensive data available to quantify this class of investments is **agricultural gross fixed capital formation (AGFCF)** compiled by the FAO of the United Nations (FAO, 2019). The data are reported at current prices in millions of US dollars, and include the flow of real capital (physical assets), such as plantation crops, livestock, land development, machinery and equipment, and farm structures used in crop production and animal rearing.

3.5.3 Measure for Domestic Public Investments

Domestic public investments in agriculture are of two categories namely: (i) general government expenditure on agriculture; and (ii) public spending on agricultural research and development (R&D) (FAO, 2019).

The most comprehensive and open source data available to quantify **general government expenditure on agriculture** is obtainable from the Statistics on Public Expenditures for Economic Development (SPEED) database (IFPRI, 2015). The Values are provided at constant 2005 prices in billions of US dollars. The SPEED database is compiled by the International Food Policy Research Institute (IFPRI) mainly using the IMF Government Financial Statistics Yearbook, supplemented with information from country publications from the IMF, public expenditure reviews by the World Bank, and country publications from various government agencies (IFPRI, 2015). It provides data on 147 low-, middle-, and high-income countries in the crop production and animal husbandry sectors. General government spending on agriculture consists of central, state, and local government funds, as well as social security funds.

Spending on agricultural R&D is excluded and reported separately from general government expenditures on agriculture (IFPRI, 2019). The Agricultural Science and Technology Indicators (ASTI) database provides the most comprehensive and open source data available to quantify **public spending on agricultural research and development (R&D)** (IFPRI, 2019). The Values are provided at constant 2011 prices in millions of US dollars. The ASTI database is also compiled by the IFPRI (IFPRI, 2019), and it provides data on 90 low- and middle-income countries. The data collected are actual spending data, not budgeted or projected data, reported on a calendar-year basis (IFPRI, 2019). Agricultural R&D includes crops, livestock, fishery, forestry, natural resources, as well as on-farm postharvest research expenditures.

3.5.4 Measure for Foreign Private Investments

The best available measure of foreign private investment in agriculture and related sectors comes from data on **foreign direct investment (FDI)** inflows (FAO, 2019). As earlier mentioned, FDI inflows are often regarded as a growing source of finance with major potential for agricultural growth and development (FAO, 2019). However, because of the lack of comprehensive information, due to poor reporting, collection, dissemination, and sometimes confidentiality of data, arriving at exact and reliable estimates of FDI in agriculture is difficult (FAO, 2019). This section of the analysis uses data from the United Nations Conference on Trade and Development (UNCTAD), whose database contains the most comprehensive data on FDI (UNCTAD, 2019). The UNCTAD provides data on FDI in the agriculture sector (agriculture, hunting, forestry, and fishing) and the food sector (food, beverages, and tobacco). Data are provided at current prices in millions of US dollars.

3.5.5 Measure for Foreign Public Investment

According to the FAO (2019), foreign public investments in agriculture by bilateral donors, international organisations, and private foundations are usually measured in terms of **development flows to agriculture (DFA)**. The most comprehensive data set for this measure is compiled by the FAO of the United Nations (FAO, 2019). The data are reported at current prices in millions of US dollars. The development flows to agriculture comprise of Official Development Assistance (ODA) flows, Other Official Flows (OOFs), and Private Grants/Flows reported by donor countries, multinational organisations, and private foundations (FAO, 2019). The sectors covered include crops, livestock, fishery, and forest resources.

3.5.6 Measure for Credit to Agriculture

The FAO (2019) defines **credit to agriculture** as the value of loans provided to producers in crop production, animal husbandry, fishery, and forest resources by the private/commercial banking sector. Producers include household producers, cooperatives, and agro-businesses. Agricultural credit enables farmers to invest in machinery and equipment, improving technologies, and other farm inputs/activities that lead to increased productivity (Kohansal, Ghorbani, & Mansoori, 2008). It is an important tool utilised to develop rural areas in developing countries (Kohansal, et al., 2008). Credit accessibility is also important for improving the quality of farm products (Kohansal, et al., 2008). The data for the credit to agriculture variable is obtainable from the FAO database of the United Nations. The data are reported at current prices in millions of US dollars. Studies examining the role of agricultural credit in growing and developing the agricultural sector include: Sogo-Temi and Olubiyo (2004); Rehman, Chandio, Hussain, and Jingdong (2017); Obilor (2013); and Abedullah, Mahmood, and Kouser (2009). The results of the studies show that agricultural credit plays a significant role in the development of the agricultural sector and economy at large.

3.5.7 Measure for Agricultural Policy

Agricultural policies are essential in sustaining supply levels, ensuring price stability, setting product quality standards, creating employment, etc. These policies themselves are influenced by factors such as government savings, the size of public spending, population pressure and food security issues, etc. A priori, agricultural policies can be quantitatively measured using individual policy frameworks such as, agricultural imports, agricultural subsidies, etc., or qualitatively measured by using binary dimensions. Since agricultural policy framework is designed to increase or stabilise agricultural output levels, an efficient way to quantitatively measure/capture the composite impact of agricultural policies on investments in agriculture is to assess the ratio of agricultural output to GDP.

The UNCTAD (2019) calculates agricultural output-to-GDP ratio by diving the value of agricultural output by (nominal) GDP. The higher the ratio, the stronger are the agricultural policies. Data for agricultural output-to-GDP ratio are obtainable from the UNCTAD database. Studies examining the impact of agricultural policies on agricultural sector performance include: Ode-Omenka (2018) and Ogwumike and Ozughalu (2014). While the result of the former reveals a positive and significant impact of agricultural policies on agricultural sector performance, the later reveal a positive but insignificant impact.

3.5.8 Measure for Exchange Rate

The FAO (2019) defines (nominal) **exchange rate** as the price in domestic currency of one unit of a foreign currency, and could be any one of the following: (i) a market rate in which the rate floats and is determined mainly by market forces; (ii) an official or fixed rate, determined by a governing body (usually the central bank); or (iii) a principal, secondary, or tertiary rate, for countries operating a multiple exchange rate system. Exchange rate is important to this study because it drives foreign investments, as well as influences stakeholder capacity to invest in the imports of agricultural inputs. Annual exchange rate data are obtainable from the FAO database of the United Nations. The data are provided in nominal terms, U.S. dollar per national currency units. Studies examining the role exchange rate plays on agricultural sector performance include: Anowor, Ukweni, and Martins (2013) and Joel and Glory (2018). While the result of the former reveal a positive but insignificant impact of exchange rate on agricultural sector performance, the later reveal a positive and significant impact.

3.5.9 Measure for Trade Openness

The UNCTAD (2019) defines **trade openness** as the outward or inward orientation of a country‟s trade policy in relation to its GDP. In other words, trade openness is the degree to which trade transactions occur and the impact on the economy. Trade openness creates opportunities for domestic firms to access cheaper and superior quality inputs, technologies, and managerial skills from abroad (Miller & Upadhyay, 2000). Correspondingly, a trade liberalized economy allows cost-efficient producers to expand their output beyond the domestic market (Krugman, 1990). A key determinant of the effect of foreign public investments on agricultural sector performance and the overall growth of the economy is the degree of trade openness (Sakyi, 2011; Burnside & Dollar, 2000). With all things being equal, trade openness fosters agricultural productivity (De Silva, Malaga, & Johnson, 2013; Hassine, Robichaud, & Decaluwe, 2010). It fosters productivity by exploiting comparative advantages gained through exposure to foreign competition, technical advancement, and economies of scale (Jayanthakumaran, 2002).

The UNCTAD (2019) calculates trade openness (or trade-to-GDP ratio) as the average of imports and exports divided by (nominal) GDP. Average of imports and exports, which indicates approximately the size of international trade, is the sum of imports and exports values divided by two (UNCTAD, 2019). The higher the ratio, the more the country is exposed to international trade. Data for trade-to-GDP ratio are obtainable from the UNCTAD database. Studies examining the role trade openness plays on agricultural sector performance include: De Silva, Malaga, and Johnson (2013); Hassine, Robichaud, and Decaluwe (2010); and Verter (2016). The results of these studies indicate a positive and significant impact of trade openness on agricultural sector performance.

Table 2 provides a summary of the description of and measure for each variable constituting the augmented regression model.

Table 2 Measurement of Variables

S/N	Variable	Description	Measure
1	AOI	Agricultural Output Index	Agricultural Output Index
2	DPRI	Domestic Private Investments	Agricultural Gross Fixed Capital Formation
3	DPGE	Domestic Public Investments in terms of General Government Expenditure on Agriculture	General Government Expenditure on Agriculture
4	DPRD	Domestic Public Investments in terms of Public Spending on Agricultural Research and Development {R&D}	Public Spending on Agricultural R&D
5	FPRI	Foreign Private Investments	Foreign Direct Investments (Inflows)
6	FPUI	Foreign Public Investments	Development Flows to Agriculture
7	CRA	Credit to Agriculture	Credit to Agriculture
8	AP	Agricultural Policy	Agricultural Output-to-GDP Ratio
9	EXRT	Exchange Rate	Exchange Rate
10	TROP	Trade Openness	Trade-to-GDP Ratio

Source: Author’s Compilation.

3.6 Sources of Data

Given the nature of the study, the output model was constructed using (secondary) annual balanced panel data on 36 member-countries of the African Union covering the period of 1980 - 2018. Panel (or pooled) data regression models are observations on individual units of cross-sections over several time periods. A balanced panel has the same number of time observations for each cross-sectional unit. With 36 cross sectional units (i.e., 36 countries) each having 39 time observations (i.e., 39 years), this study has a total of 1,404 observations (i.e., 36 countries X 39 years). Because panel data have time as well as space dimensions, the variables in the (generic) regression model (5) bear the appropriate subscripts, "**i**," denoting the cross-section identifier (i.e., country) and "**t**," denoting the time identifier (i.e., year). The sources of these data are outlined in Table 3.

Table 3 Data Sources

S/N	Variable Measure	Period	Data Property	Data Source
1	Agricultural Output Index	1980 – 2018	Annual Data	The Food and Agricultural Organisation (FAO) of the United Nations (MEASURE - Index)
2	Agricultural Gross Fixed Capital Formation	1980 – 2018	Annual Data	The FAO of the United Nations (MEASURE – US Dollars at current prices in millions)
3	General Government Expenditure on Agriculture	1980 – 2018	Annual Data	The Statistics on Public Expenditures for Economic Development (SPEED) database of the International Food Policy Research Institute (IFPRI) (MEASURE - US Dollars at constant 2005 prices in billions)
4	Public Spending on Agricultural R&D	1980 – 2018	Annual Data	The Agricultural Science and Technology Indicators (ASTI) database of the IFPRI (MEASURE – US Dollars at constant 2011 prices in millions)
5	Foreign Direct Investments (Inflows)	1980 – 2018	Annual Data	The United Nations Conference on Trade and Development (UNCTAD) (MEASURE – US Dollars at current prices in millions)
6	Development Flows to Agriculture	1980 – 2018	Annual Data	The FAO of the United Nations (MEASURE – US Dollars at current prices in millions)
7	Credit to Agriculture	1980 – 2018	Annual Data	The FAO of the United Nations (MEASURE – US Dollars at current prices in millions)
8	Agricultural Output-to-GDP Ratio	1980 – 2018	Annual Data	The UNCTAD (MEASURE – Ratio)

9	Exchange Rate	1980 – 2018	Annual Data	The FAO of the United Nations (MEASURE – US dollar per national currency unit)
10	Trade-to-GDP Ratio	1980 – 2018	Annual Data	The UNCTAD (MEASURE – Ratio)

Source: Author's Compilation.

3.6.1 Dynamics of Investments and Productivity

A critical issue relating to studies involving investments and production data is identifying the time lag with which investments impact productivity. According to the FAO (2019), capital investments by definition impact production in more than one year. In addition, the contribution of capital to production diminishes or depreciates over time (diminishing marginal productivity). Chavas and Cox (1992) report that at least 30 years are required to fully capture the effects of investments on agricultural productivity. The time period selected for this study (i.e., 39 years) suffices as it is consistent with the observation of Chavas and Cox (1992). It is however important to mention that certain statistical procedures and estimation techniques were used to fill data gaps in order to maximize the estimation efficiency.

3.6.2 Capital and Recurrent Expenditures

The data compiled by the IFPRI (2015) on general government expenditure on agriculture is not segregated between capital expenditure and recurrent expenditure. This information is vital in distinguishing between the impacts of investments and spending on operating inputs. Additionally, the data does not distinguish between budget and actual expenditures. This information is an important tool in the monitoring and evaluation of government sponsored programmes and activities. Notwithstanding, Public Expenditure Reviews (PERs) are documented reports from which these types of information may be sourced. The content and format of these reviews vary significantly, due to differences in purpose, approach, period, and sectorial coverage.

3.6.3 Sector Composition

Data on the different categories of investments in agriculture measure different types of sectors in agriculture (FAO, 2019). Agricultural gross fixed capital formation and general government expenditure capture data on the crops and livestock sectors, but exclude the fishery and forestry sectors. Public spending on agricultural R&D, foreign direct investments, and development flows to agriculture report on all four sectors. Also, the agricultural output index captures only the crops and livestock sectors (FAO, 2019).

3.6.4 Valuation of Data

Data on domestic public investments in agriculture, general and R&D, are reported in constant prices 2005 US dollars (IFPRI, 2015) and 2011 US dollars (IFPRI, 2019), respectively, whereas the data on the other investment variables, AGFCF, FDI, and DFA, as well as CRA are reported in current prices US dollars (FAO, 2019).

3.6.5 Double Counting of Data

Some DFA are provided to governments and reported in their spending on agriculture, be it general or R&D. Likewise, some government expenditures on agriculture, be it general or R&D are provided to farmers and reported as agricultural capital stock. The same principle may apply to FDI presented to farmers and reported as agricultural capital stock. Thus, there may be some double counting of data between these variables (FAO, 2019).

These data limitations are beyond the control of the researcher. Despite these limitations, the data compiled and analyzed for this study provide the most comprehensive, comparable, and open source estimates of investments in agriculture for Africa that exist to date (FAO, 2019).

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CHAPTER FOUR

RESULTS PRESENTATION AND ANALYSES

4.1 Patterns of investments in agriculture in Africa.

The broad objective of this study is to analyse the impact of investments in agriculture on agricultural output in Africa. This section addresses the first specific research objective, which is to examine the patterns of investments in agriculture in Africa.

Table 4 shows the relative size of the investment categories in African Agriculture and the impact on agricultural output from 1980-2018. This table produces Figures 1 to 7 only, and does not constitute the panel data applied in section 4.2 of the study.

Table 4 Relative Size of Investment Categories in African Agriculture and Impact on Agricultural Output, 1980-2018.

Year	AOI	DPRI	DPGE	DPRD	FPRI	FPUI
1980	2,970	2,271	3,446	551	400	47
1981	3,103	2,434	3,838	562	1,953	61
1982	3,134	2,608	4,179	577	2,074	88
1983	3,082	2,796	4,278	574	1,323	52
1984	3,115	2,996	3,627	560	1,885	46
1985	3,310	3,211	3,689	550	2,442	61
1986	3,446	3,442	3,877	548	1,770	106
1987	3,466	3,689	3,339	591	2,443	83
1988	3,582	3,953	3,423	587	3,032	143
1989	3,686	4,237	3,994	595	4,693	77
1990	3,713	4,541	3,440	595	2,845	382
1991	3,951	4,867	3,111	692	3,536	542
1992	3,887	5,216	3,251	686	3,801	858
1993	4,099	5,590	3,607	677	5,444	767
1994	4,138	5,991	4,434	699	6,104	427
1995	4,226	6,421	4,461	656	5,665	594
1996	4,491	7,575	4,363	685	6,048	1,140
1997	4,522	7,558	4,212	656	11,030	950
1998	4,695	7,534	4,850	744	9,991	926
1999	4,867	7,295	6,303	688	11,892	970
2000	4,922	6,834	5,176	739	9,651	1,396
2001	5,077	6,618	6,285	819	19,973	1,821
2002	5,050	7,174	5,927	840	14,766	1,740
2003	5,294	7,835	5,713	840	18,178	2,247
2004	5,429	8,243	5,971	903	17,676	2,498
2005	5,606	9,295	6,951	888	29,433	2,765
2006	5,764	11,103	6,907	925	34,625	3,075

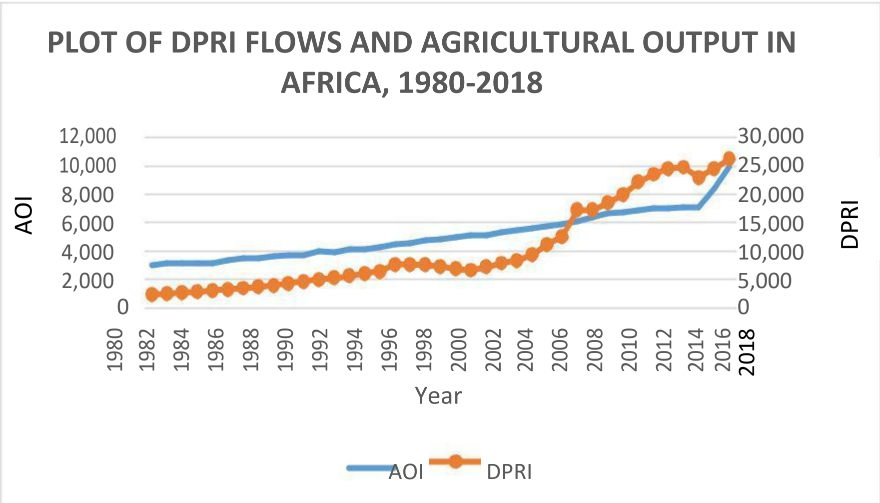
2007	5,834	12,496	7,159	948	51,062	3,806
2008	6,092	17,211	7,801	1,013	58,060	4,191
2009	6,318	17,180	6,993	2,108	56,652	5,659
2010	6,669	18,424	5,984	2,104	46,620	6,090
2011	6,730	19,873	6,026	2,111	45,633	7,163
2012	6,866	22,133	4,005	2,234	56,854	6,345
2013	7,015	23,475	4,060	1,125	50,075	7,959
2014	7,008	24,553	4,116	1,151	53,906	8,301
2015	7,077	24,755	4,172	586	56,874	7,649
2016	7,095	22,957	4,230	525	46,482	8,035
2017	8,397	24,494	4,288	536	41,390	8,940
2018	9,939	26,134	4,347	547	45,902	11,221
TOTAL	197,665	405,009	185,830	33,415	842,186	109,222

Note: AOI figures are in Index. DPRI, FPRI, and FPUI figures are in Current prices millions US Dollars, while DPGE and DPRD figures are in Constant 2005 and 2011 prices millions US Dollars, respectively.

Source: Author's Compilation from the FAO, IFPRI, and UNCTAD Websites.

Figures 1 to 6 show the trends in agricultural investment flows in Africa for almost three decades.

Figure 1



DPRI started with an upward trend and expanded rapidly from the early 2000s. This is not surprising given that the development strategy of the Comprehensive Africa Agriculture Development Programme (CAADP) is to grow the agricultural sector through increased participation of domestic private investors. Domestic private investors also benefited from the increased agricultural credit extended to them, amongst other favourable agricultural policies that created an enabling environment for them to thrive.

Figure 2

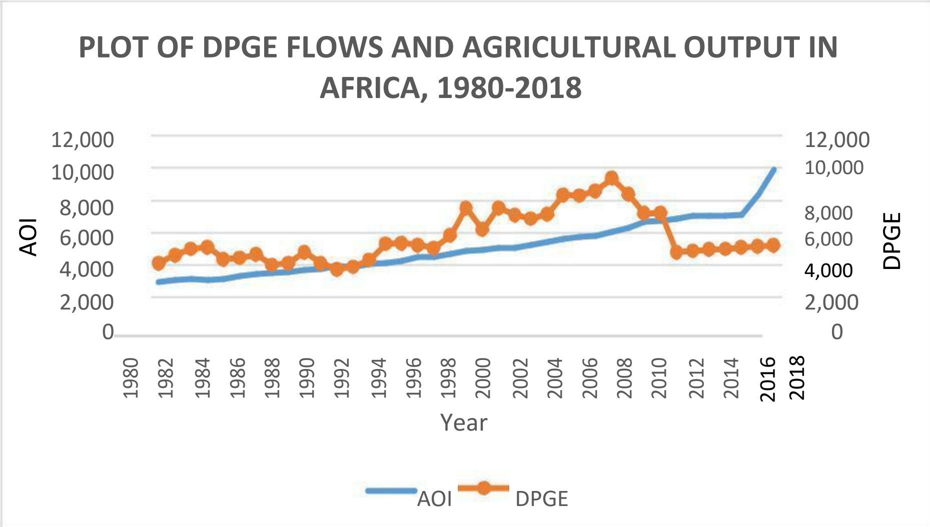
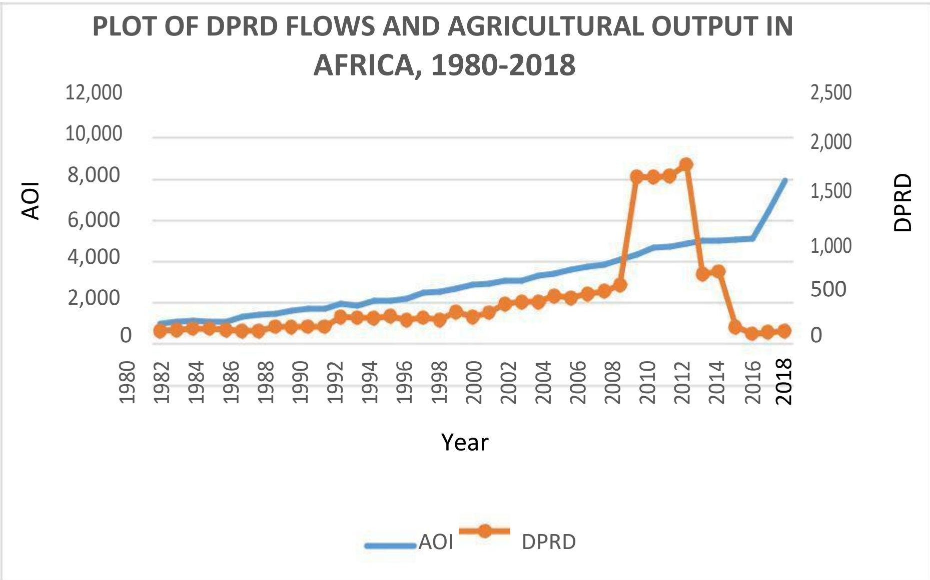
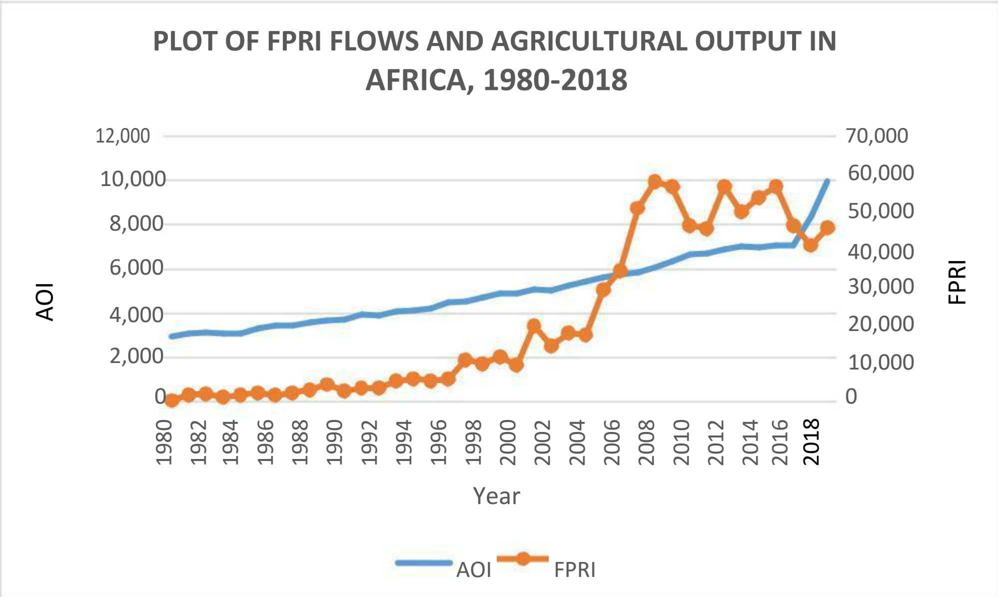


Figure 3



Though DPGE and DPRD started with a slight upward trend, the CAADP had minimal impact on them as compared to DPRI. In other words, there is no noticeable growth surge in DPGE and DPRD in the early 2000s to coincide with the launching of the CAADP in 2003. DPGE peaked in 2008, while DPRD peaked in 2012, but dropped almost immediately after and never attained the same heights. Recall that the 10% pledge of agricultural expenditure was to be executed by year 2008, and the 6% annual growth in agricultural output was to be achieved by year 2015. Thus, a plausible explanation for this trend is that in a last minute attempt to achieve the Maputo targets, some governments pumped resources in to the agricultural sector of their respective economies, but since the vast majority of governments were really not committed to the realisation of the goals stipulated in the Maputo declaration of 2003, their investment efforts subsided. Substantiating this statement is the report presented by the NewAfrican (2014), stating that only 20% of Sub-Saharan African (SSA) countries had met the Maputo target.

Figure 4



FPRI started with an upward trend, expanded rapidly from the early 2000s, and took an exponential leap in 2004. FPRI has evolved from an activity mostly undertaken by a few large multinational enterprises (MNEs) to a global phenomenon. These large enterprises have now been joined by small and medium-scale enterprises (SMEs), as well as countries, channeling goods, services, capital, labour, and technology worldwide. The exponential increase in FPRI flows in Africa is attributable to several inter-related factors at the national, continental, and global levels, such as, rapid technological progress, trade and investment liberalisation, privatisation and de-monopolisation,

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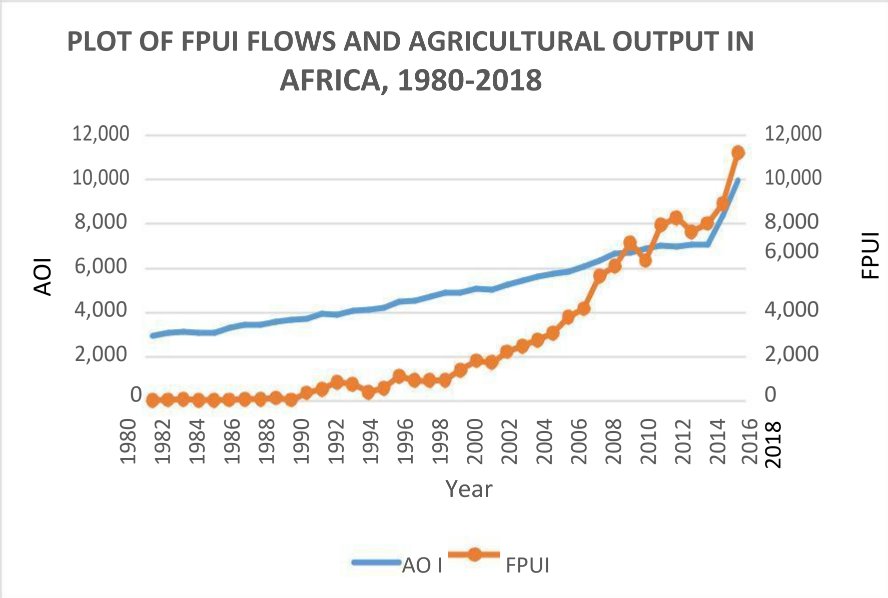
deregulation and de-bureaucratisation, as well as the change in philosophy by foreign private investors from product diversification to emphasis on geographical distribution of production and sales (Thomsen, 2000).

Figure 5



FPUI started with an upward trend and expanded rapidly from the early 2000s. The rapid expansion of FPUI flows in Africa is mostly as a result of aid receipts from development partnerships forged with donor countries, multinational organisations, and private foundations targeted at domestic private investors to stimulate domestic production.

Figure 6

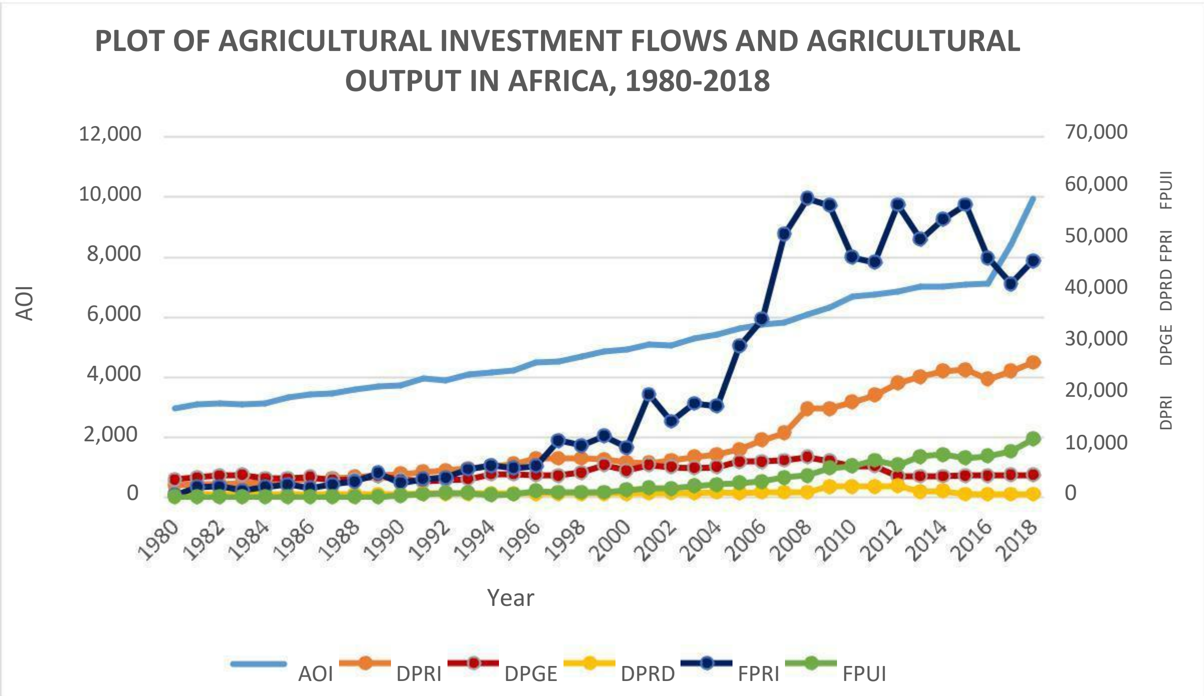
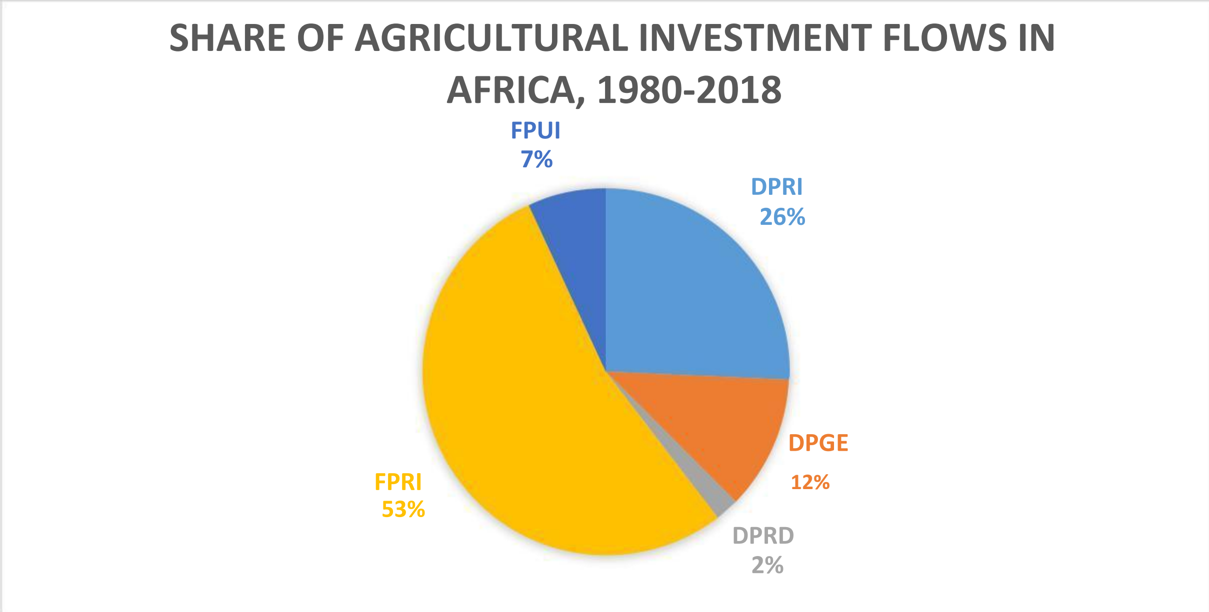


Figure 6 shows a diagrammatic relationship between all the categories of investments in agriculture and agricultural output in Africa from 1980-2018. The upward trend of agricultural output over time is immediately apparent. This trend reveals a highly impactful relationship between agricultural investments and agricultural output. The impact is mostly substantiated by the noticeable upward trends of FPRI, DPRI, and FPUI beginning in the early 2000s.

Figure 7 shows the share of agricultural investment flows in Africa from 1980 to 2018.

Figure 7



FPRI accounts for about half, that is, 53% of agricultural investment flows in Africa. At 26%, DPRI accounts for about a quarter of agricultural investment flows in Africa, which is also about half of FPRI. DPGE and DPRD stand at 14%, which is about half of DPRI. Lastly, FPUI is at 7%, which is half of DPGE and DPRD. Thus, from 1980 to 2018, FPRI had the largest share of agricultural investment flows in Africa, followed by DPRI, DPGE and DPRD, and lastly, FPUI.

Agricultural growth influences both the supply of and demand for investment flows in agriculture. The Maputo convention of 2003 is a classic example of how a conscientious effort to grow agriculture in

Africa can lead to increased supply of and demand for investment flows. Thus, the performance of a country in terms of investment flows is usually predicated on sound investment policies, as well as its relative attractiveness as a destination for foreign investments (FAO, 2013; OECD, 2013).

In terms of what the future patterns of agricultural investments will be for Africa, the expectation is that over time, the upward trend of FPRI is likely to return to equilibrium, especially given the reality of the business cycle and potential volatility of investment flows (Thomsen, 2000). Furthermore, considering all the national and continental development strategies to grow African agriculture through increased participation of domestic private investors, DPRI, if employed optimally in furthering the growth of agriculture is bound to overtake FPRI as the largest share of agricultural investment flows in Africa.

4.2 Impact of the categories of investments in agriculture on agricultural output in Africa.

This section addresses the second specific research objective, which is to estimate the impact of the categories of investments in agriculture on agricultural output in Africa.

4.2.1 Descriptive Statistics

This section of the study seeks to provide an analytical discussion on the descriptive statistics of the variables constituting the augmented regression model designed for the study. Table 5 reports the output of the descriptive statistics of the study.

Table 5 Descriptive Statistics.

	AOI[a]	DPRI[b]	DPGE[c]	DPRD[b]	FPRI[b]	FPUI[b]	CRA[b]	AP[d]	EXRT[d]	TROP[d]
Mean	4.4173	17.998	17.513	16.124	16.452	12.951	12.019	3.0561	-3.4972	3.2131
Median	4.4855	17.973	18.031	16.171	18.076	15.560	15.556	3.3136	-4.0692	3.3181
Minimum	3.2929	12.778	-1.0000	10.292	-1.0000	-35.047	-3.4524	0.70916	-8.9786	0.00000
Maximum	5.3427	22.307	42.011	21.233	23.172	22.316	21.829	4.3884	7.1309	4.9076
Standard Deviation	0.38596	1.7559	3.8742	1.5529	5.9231	6.9472	8.1119	0.74911	2.8762	0.86602
Coefficient of Variation	0.087374	0.097559	0.22122	0.096307	0.36003	0.53643	0.67493	0.24512	0.82242	0.26953
Skewness	-0.40542	0.040817	-0.64784	-0.39372	-2.1190	-1.8394	-0.67173	-0.88155	0.51294	-2.1261
Excess Kurtosis	-0.10173	-0.43987	13.729	0.72236	3.6612	4.0624	-1.2862	0.16045	-0.17789	5.9700
5%	3.7251	15.108	12.130	13.319	-1.0000	-1.0000	0.00000	1.5335	-7.3302	1.8999
95%	5.0216	21.041	20.670	18.661	21.628	18.883	20.717	3.9449	0.22504	4.2252
IQ range	0.50271	2.4799	2.3521	1.7590	3.9185	4.5059	18.401	1.0639	5.1417	0.74079
Missing obs.	0	0	0	0	0	0	0	0	0	0

a – Figures in Index

b – Figures in Millions of US Dollars

c – Figures in Billions of US Dollars

d – Figures in Percentage

Source: Author's Compilation from the Gretl output of Descriptive Statistics.

Over the period of 1980 to 2018, agricultural output index (AOI) on average is 4.4173 in Africa, with minimum and maximum output levels of 3.2929 and 5.3427, respectively. Considering the minimum and maximum output levels, the average level of output suggests steady production over the years in Africa.

Domestic private investments (DPRI) on average is $17.998 Million in Africa, with minimum and maximum investment levels of $12.778 Million and $22.307 Million, respectively. Considering the minimum and maximum investment levels, the average level of domestic private investments suggests steady levels of investments over the years by domestic private investors in Africa.

Domestic public investments in terms of general government expenditure on agriculture (DPGE) on average is $17.513 Billion in Africa, with minimum and maximum investment levels of -$1.0000 Billion and $42.011 Billion, respectively. The minimum and maximum levels of this investment category suggests inconsistent levels of investments in agriculture by African governments over the period of 1980 to 2018.

Domestic public investments in terms of public spending on agricultural research and development (DPRD) on average is $16.124 Million in Africa, with minimum and maximum investment levels of $10.292 Million and $21.233 Million, respectively. Considering the minimum and maximum investment levels, the average spending on agricultural research and development suggests steady levels of investments in research and development over the years by African governments.

Foreign private investments (FPRI) on average is $16.452 Million in Africa, with minimum and maximum investment levels of -$1.0000 Million and $23.172 Million, respectively. The minimum and maximum levels of this investment category suggests unstable levels of foreign private investments in agriculture over the years in Africa.

Foreign public investments (FPUI) on average is $12.951 Million in Africa, with minimum and maximum investment levels of -$35.047 Million and $22.316 Million, respectively. The minimum and maximum levels of this investment category suggests highly unsteady levels of foreign public investments in agriculture over the years in Africa.

Credit to agriculture (CRA) on average is $12.019 Million in Africa, with minimum and maximum credit levels of -$3.4524 Million and $21.829 Million, respectively. The minimum and maximum credit levels suggests inconsistent levels of credit extended to agriculturalists over the years in Africa.

Agricultural policy (AP) on average is 3.0561%, with minimum and maximum percentage levels of 0.70916% and 4.3884%, respectively. The interpretation of this result is that on average, agriculture accounts for only 3.0561% of GDP in Africa. Though the level of output appears to be steady at an average of 3.0561% considering the minimum and maximum levels of outputproduction, the average production level over the years is extremely low given Africa‟s enormous resources in arable land and labour factors. The implication of the result is that agricultural policies in Africa over the years have not been very effective in bridging Africa‟s agricultural output gap, as well as meeting the sustainable development goals (SDGs) of food security and poverty eradication.

Exchange rate (EXRT) on average is observed to have been -3.4972% over the period of 1980 to 2018, with minimum and maximum rate levels of -8.9786% and 7.1309%, respectively. Considering the minimum and maximum rate levels, and the challenges African nations face in implementing sound fiscal and monetary policies, the exchange rate mean figure of - 3.4972% is considered to have been steady over the years. The interpretation of this result is that on average, the exchange rate in Africa was low over the period of 1980 to 2018. The implication of a low exchange rate (i.e., depreciation or devaluation of the national currency) on agricultural output is two folds: first, a low exchange rate attracts foreign investments, which in turn could lead to higher output levels; and second, a low exchange rate reduces the capacity of stakeholders to invest in the imports of agricultural inputs, which in turn could lead to lower output levels.

Trade openness (TROP) on average is 3.2131%, with minimum and maximum percentage levels of 0.00000% and 4.9076%, respectively. The interpretation of this result is that on average, trade accounts for only 3.2131% of GDP in Africa. Though the level of trade appears to be steady at an average of 3.2131% considering the minimum and maximum levels of trade, the average trade level over the years is extremely low given Africa‟s enormous tradable resources in agriculture, mining, and human capital. The implication of the result is that trade liberalisation policies in Africa over the years have not been very effective in bringing about the much anticipated increase in agricultural output. Furthermore, Africa is not doing enough to harness all her natural and human resources to maximise the agricultural growth opportunities from increased international exposure in the world trading space. Standard deviation (Std. Dev.) measures the average distance between the values of the data in a set and the mean or expected value. A low std. dev. indicates that the data points will tend to be very close to the mean, while a high std. dev. shows that the data points will be spread out or dispersed over a large range of values from the mean. Usually between 0 and 1, the coefficient of variation (C.V.) shows the extent of variability of data in a sample in relation to the mean. In other words, it is the ratio of the standard deviation to the mean. Thus, the higher the C.V., the greater the level of dispersion around the mean, but the lower the C.V., the lower the level of dispersion, and hence, the more precise the estimate of the mean value (Gujarati, 2003).

The C.V. for the variables in Table 5 are as follows: AOI 0.087374; DPRI 0.097559; DPGE 0.22122; DPRD 0.096307; FPRI 0.36003; FPUI 0.53643; CRA 0.67493; AP 0.24512; EXRT 0.82242; and TROP 0.26953. All the C.V. values are between 0 and 1; thus, it can be inferred that the corresponding std. dev. values are tolerable. All the C.V. values with the exception of the CRA and EXRT variables are relatively closer to 0 than to 1, indicating higher precision in the estimates of their respective mean values.

Skewness is a statistical analysis that is employed to measure the departure from symmetry. A distribution or data set is said to be symmetric if it is spread out evenly to the left and right of the centre point; in such an instance, skewness is zero. Positive values for skewness indicate data that are skewed right or positively skewed, while negative values indicate data that are skewed left or negatively skewed (Gujarati, 2003).

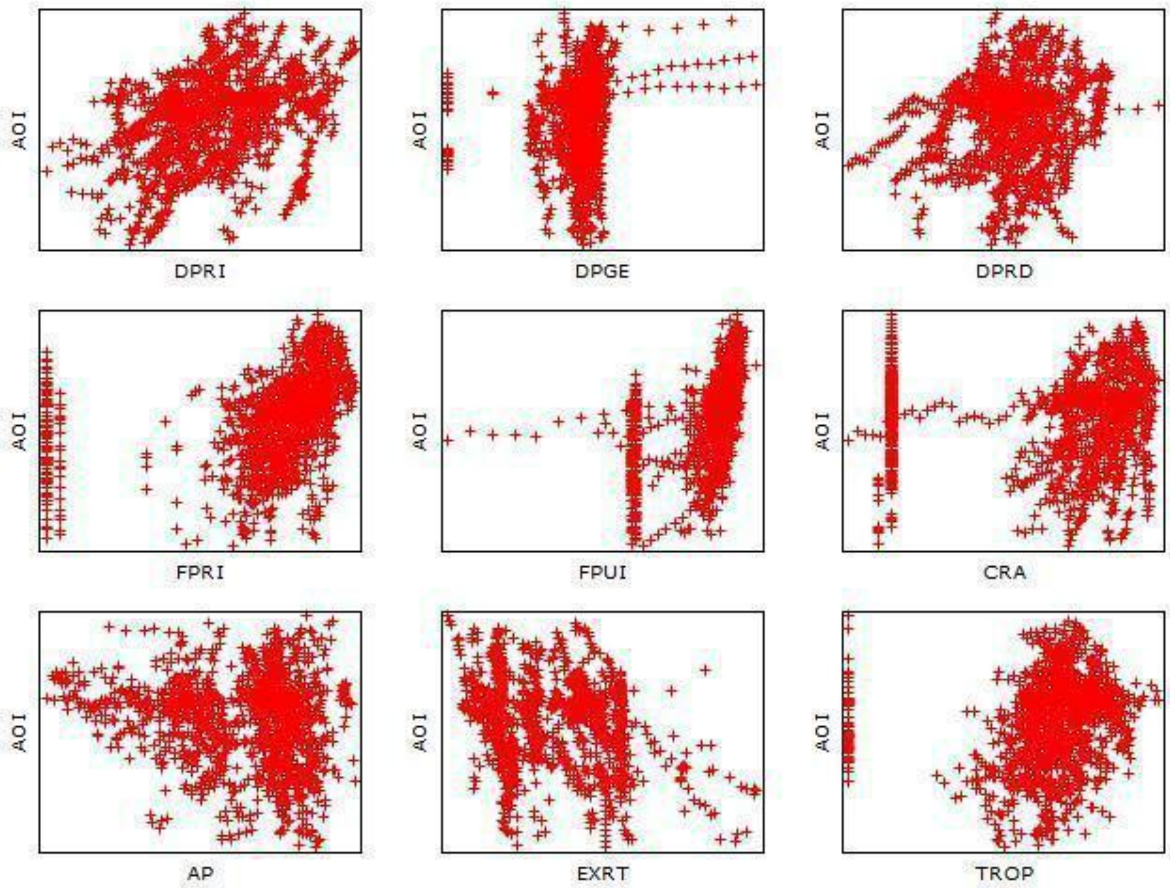
Variables AOI, DPGE, DPRD, FPRI, FPUI, CRA, AP, and TROP with values -0.40542, - 0.64784, -0.39372, -2.1190, -1.8394, -0.67173, -0.88155, and -2.1261, respectively, are negatively skewed, while variable EXRT with value 0.51294 is positively skewed. Variable DPRI with value 0.040817 is symmetric.

Kurtosis measures the degree of peakedness or flatness of data relative to data normal distribution. The normal distribution has a kurtosis of 3. Excess kurtosis (Ex. kurtosis) is simply defined as kurtosis minus 3 (i.e., kurtosis – 3). Ex. kurtosis for the normal distribution is therefore 0 (i.e., 3 - 3 = 0). The normal distribution is a symmetric distribution with kurtosis of 3 or Ex. kurtosis of 0. A distribution with kurtosis or Ex. kurtosis above that of the normal distribution indicates data that are peakedness or lapto-kurtic, while a distribution with kurtosis or Ex. kurtosis below that of the normal distribution indicates data that are flat or plato-kurtic. A distribution with kurtosis or Ex. kurtosis at normal distribution is mesokurtic. In other words, a distribution with kurtosis > 3 or Ex. kurtosis > 0 indicates data that are peakedness or lapto-kurtic, while a distribution with kurtosis < 3 or Ex. kurtosis < 0 indicates data that are flat or plato-kurtic. A distribution with kurtosis of 3 or Ex. kurtosis of 0 is mesokurtic (Gujarati, 2003).

Ex. kurtosis for variables DPGE, DPRD, FPRI, FPUI, AP, and TROP are all > 0, i.e., 13.729, 0.72236, 3.6612, 4.0624, 0.16045, and 5.9700, respectively, indicating that the distributions are peaked relative to data normal distribution or lapto-kurtic. Ex. kurtosis for variables AOI, DPRI, CRA, and EXRT are all < 0, i.e., -0.10173, -0.43987, -1.2862, and -0.17789, respectively, indicating that the distributions are flat relative to data normal distribution or plato-kurtic.

Figure 8 shows the Scatter Diagram (or scatter-plot) of each independent variable of the augmented regression model plotted against the dependent variable. The Scatter-plots provide a diagrammatic view of the level of Ex. kurtosis embedded in each Variable (Gujarati, 2003).

Figure 8 Scatter-plot of each Independent Variable against the Dependent Variable



Per examination of the scatter-plots in Figure 8, it can be observed that variables DPGE, FPRI, FPUI, CRA, and TROP have less variability and outliers in the distribution. Less variability in the distribution implies that the data points are clustered. Simply put, the outliers in these graphs are the data points that seem to drift and break away from the cluster. It can also be observed that variables DPRI, DPRD, AP, and EXRT have more dispersion and lack outliers in the distribution. More dispersion in the distribution implies that the data points are not clustered. Also, the graphs do not seem to have data points that drift and break away from the cluster.

Data sets or distributions with high Ex. kurtosis tend to have less variability and outliers, while distributions with low Ex. kurtosis tend to have more dispersion and lack outliers (Gujarati, 2003). Thus, it can be inferred that variables DPGE, FPRI, FPUI, CRA, and TROP, with Ex. kurtosis values 13.729, 3.6612, 4.0624, -1.2862, and 5.9700, respectively, have high Ex. kurtosis, while variables DPRI, DPRD, AP, and EXRT, with Ex. kurtosis values - 0.43987, 0.72236, 0.16045, and -0.17789, respectively, have low Ex. kurtosis. The low value of -0.10173 reported for variable AOI suggests that it has low Ex. kurtosis. The large variation of observations, including the outliers in Figure 8 suggests that other factors are relevant, such as the composition and quality of expenditure on agriculture, in determining the effectiveness of investments in promoting agricultural output.

4.2.2 Test for Normality of Variables

According to Ghasemi and Zahediasl (2012), many parametric tests (e.g., correlation, regression, t-tests, analysis of variance, and other statistical procedures) are based on the assumption that the data follow a normal distribution, because their validity depends on it. In other words, for a parametric test to be valid, it is assumed that the population from which the sample is drawn is normally distributed.

In determining normal distribution of the random variables employed in this study, the Jarque-Bera test (JBT) was applied. The null hypothesis for this test is that the sample distribution is normal. The decision rule for the test is that, if the p-value of the computed JBT statistic is less than the 5% (or 0.05) significance level of the study, then the null hypothesis is rejected that the distribution is normal (Gujarati, 2003).

Table 6 Test for Normality of Variables

	Jarque-Bera Test (JBT)	
	JBT-statistic	p-value
AOI	39.0673	3.28588e-009
DPRI	11.709	0.00286701
DPGE	11124.4	0
DPRD	66.8002	3.12259e-015
FPRI	1834.88	0
FPUI	1757.16	0
CRA	202.369	1.13809e-044
AP	183.354	1.53207e-040
EXRT	63.4192	1.69317e-014
TROP	3142.71	0

Source: Author's Compilation from the Gretl output of Normality Test.

Table 6 reports the output of the Jarque-Bera test for normality of variables AOI, DPRI, DPGE, DPRD, FPRI, FPUI, CRA, AP, EXRT, and TROP. Since the p-values of the respective variables are below the 5% (or 0.05) significance level of the study, the null hypothesis that the random variables have a normal distribution is rejected.

However, according to Elliott and Woodward (2007), with large sample sizes (i.e., greater than 30 or 40 observations), the violation of the normality assumption is not considered a major issue; thus, parametric procedures can still be applied even when the data are not normally distributed. This is because consistent with the central limit theorem (CLT), in large samples (i.e., greater than 30 or 40 observations), the sampling distribution tends to be normal. Recall that the study has a total of 1,404 observations; thus, the consequent application of the parametric procedure of regression analysis is still in order.

4.2.3 Test for Unit Root of Variables

According to Gujarati (2003), parametric tests are also based on the assumption that the time series properties of data are free of unit root, or are stationary, because their validity depends on it; if the variables are not stationary, then the assumption of asymptotic property will not hold. A distribution is said to be stationery if its statistical properties (i.e., mean, variance, and covariance) do not change over time or are time invariant. In other words, a distribution is said to be stationery if it has a constant mean, variance, and covariance.

Because panel data have time as well as space dimensions, the random variables employed in this study were tested for stationarity using the Augmented Dickey-Fuller (ADF) Test for Unit Root. The study applies the maximum lag order of 2 and the Akaike Information Criterion (AIC) for the ADF test. This is reasonable as it is the longest lag that is statistically significant. Because of the slow long-run evolution of investments, a trend is included in conducting the ADF test. This is reasonable given that trend stationary distributions are mean-reverting. The null hypothesis for this test is that the random variable has a unit root, or is non-stationary. The decision rule for the test is that, if the p-value of the computed ADF statistic is less than the 5% (or 0.05) significance level of the study, then the null hypothesis is rejected that the random variable has a unit root, or is non-stationary (Gujarati, 2003).

Table 7 Test for Panel Unit Root of Variables

Augmented Dickey-Fuller (ADF) Test							
Variables	Level				1st Difference		Order of Integration
	Intercept		Trend and Intercept		Intercept		
	ADF statistic	p-value	ADF statistic	p-value	ADF statistic	p-value	
AOI	3.62345	0.9999	-4.01876	0.0000***	………	………	I(0)
DPRI	2.89588	0.9981	-0.2171	0.4141	-23.0458	0.0000***	I(1)
DPGE	2.27923	0.9887	-2.49377	0.0063***	………	………	I(0)
DPRD	-0.451203	0.3259	-3.78182	0.0001***	………	………	I(0)
FPRI	-9.84315	0.0000***	………	………	………	………	I(0)
FPUI	-8.96964	0.0000***	………	………	………	………	I(0)
CRA	………	………	………	………	………	………	Constant
AP	-5.21374	0.0000***	………	………	………	………	I(0)
EXRT	………	………	………	………	………	………	Constant
TROP	-1.55392	0.0601*	………	………	………	………	I(0)

*** Implies statistical significance at 1%, ** at 5%, and * at 10%.

Source: Author's Compilation from the Gretl output of Augmented Dickey-Fuller (ADF) Test.

Table 7 reports the output of the Augmented Dickey-Fuller test for unit root of random variables AOI, DPRI, DPGE, DPRD, FPRI, FPUI, CRA, AP, EXRT, and TROP. Variables FPRI, FPUI, and AP are stationary at level with intercept at 1% level of significance order of integration 0 (i.e., they are I(0) variables). Variable TROP is stationary at level with intercept at 10% level of significance order of integration 0 (i.e., it is an I(0) variable). Variables AOI, DPGE, and DPRD are stationary at level with trend and intercept at 1% level of significance order of integration 0 (i.e., they are I(0) variables). At first difference, Variable DPRI is stationary with intercept at 1% level of significance order of integration 1 (i.e., it is an I(1) variable). Recall that the ADF test result falls within a pre-established critical limit of rejection/acceptance of non-stationarity. However, this does not apply to variables CRA and EXRT, as their respective statistical properties are constant. Based on these results, the null hypothesis that the random variables have a unit root, or are non-stationary is rejected.

In theory, regression based on panel variables integrated of order 1 may be spurious as is the case with time-series; however, Kao (1999) showed that the estimate of the structural parameter binding two variables (one dependent and the other independent) integrated of order 1 converges to zero in the case of panel data, whereas in the case of time series, it is a random variable. This implies that although panel models with variables integrated of order 1 may lead to biased standard errors, the estimators of the true parameter values are consistent. Consequently, the application of panel data estimation techniques suffice.

4.2.4 Panel Model Selection: Pooled OLS, FE, and RE Models

The panel data models evaluated in this study are the Pooled Ordinary Least Squares (Pooled OLS), Fixed-Effects (FE), and Random-Effects (RE) models. Tables 8, 9, and 10 report the output of the aforementioned models, respectively, for random variables AOI, DPRI, DPGE, DPRD, FPRI, FPUI, CRA, AP, EXRT, and TROP (see Appendices for Tables 8 and 10). Each model was run using 1,404 observations, comprising 36 cross-sectional units and 39 time series. The dependent variable is AOI.

Table 9 Results of Fixed-Effects Model

Variable	Coefficient	Std. Error	t-ratio	p-value
Constant	-1.94299	0.218302	-8.900	1.74e-018***
ln DPRI	0.245457	0.00943689	26.01	2.23e-121***
ln DPGE	0.00151543	0.00169704	0.8930	0.3720
ln DPRD	0.0756958	0.00929856	8.141	8.81e-016***
ln FPRI	0.00425458	0.00113064	3.763	0.0002***
ln FPUI	0.00154128	0.00127634	1.208	0.2274
ln CRA	0.0216643	0.00313441	6.912	7.34e-012***
ln AP	0.0674358	0.0250352	2.694	0.0072***
ln EXRT	-0.0273221	0.00519480	-5.260	1.68e-07***
ln TROP	0.0135154	0.00814631	1.659	0.0973*
Mean dependent var	4.417341	S.D. dependent var	0.385961	
Sum squared resid	57.11722	S.E. of regression	0.205009	
LSDV R-squared	0.726711	Within R-squared	0.705080	
LSDV F(44, 1359)	82.13089	P-value (F)	0.000000	
Log-likelihood	255.5968	Akaike criterion	-421.1935	
Schwarz criterion	-185.0749	Hannan-Quinn	-332.9396	
Rho	0.876465	Durbin-Watson	0.233658	

*** Implies statistical significance at 1%, ** at 5%, and * at 10%.

Source: Author's Compilation from the Gretl output of Fixed-Effects Model.

The fixed-effects estimator allows for differing intercepts by cross-sectional unit. A panel diagnostic test was run to determine the joint significance of differing group means, resulting in an F-static of 48.3124 with p-value 1.3159e-210. A p-value that is below the established 5% (or 0.05) level of significance counts against the null hypothesis that the pooled OLS model is superior to the fixed-effects alternative. The random-effects estimator allows for a unit-specific component to the error term. The Breusch-Pagan LM test was run to determine the superior model between the pooled OLS model and the random-effects alternative. The result is a LM statistic of 1451.26 with p-value 0. A p-value that is below the established 5% (or 0.05) level of significance counts against the null hypothesis that the pooled OLS model is superior to the random-effects alternative.

The Hausman test was conducted to choose between the FE model and the RE model. The result is a H statistic of 536.974 with p-value 6.89834e-110. A p-value that is below the established 5% (or 0.05) level of significance counts against the null hypothesis that the random effects model is consistent, in favour of the fixed effects model. In other words, since the p-value of 6.89834e-110 is below the 5% significance level, the null hypothesis is rejected that the RE model is consistent, and thus, the FE model is the preferred model for this study.

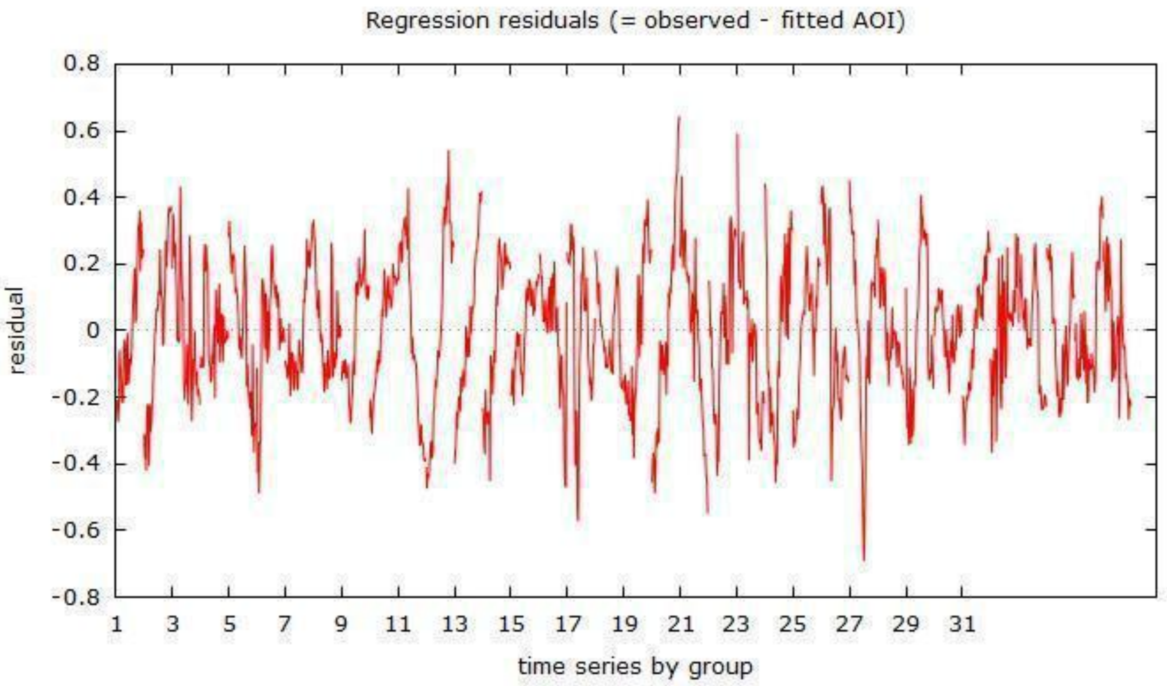
Before any tests of hypothesis can be conducted, it is essential that the required model adequacy tests are performed in order to ensure the model satisfies the assumptions of the classical normal linear regression model (CNLRM). If the model is deemed practically adequate (i.e., if the model satisfies the required normality assumptions), it may be used for forecasting future data and facilitating economic decisions. These model adequacy tests are consequently discussed in the ensuing paragraphs.

4.2.5 Test for Autocorrelation

The CNLRM assumes that the disturbance term relating to any one observation cannot be influenced by the disturbance term relating to any other observation, either within the same time series data, between two or more time series, or in cross-sectional data. In other words, correlation in the disturbances occurs when the residuals are not independent of each other within the same time series data (autocorrelation), between two or more time series‟ (serial correlation), or in cross-sectional data (spatial autocorrelation). As a point of notation, autocorrelation and serial correlation are used interchangeably in econometrics.

Because panel data have time as well as space dimensions, the data employed in this study was tested for autocorrelation. Although in the presence of autocorrelation the estimators remain unbiased, consistent, and asymptotically normally distributed, they are no longer efficient (i.e., they do not have minimum variance). In detecting autocorrelation, a prudent approach was taken with the application of both informal and formal methods. Thus, in the case of the informal method, a plot of the residuals (ε_{it}) is illustrated in Figure 9. If a systematic pattern to the disturbances (e.g., cyclical, linear, quadratic, etc.) is noted, it would suggest that the residuals are not random, or that there is autocorrelation. If on the other hand, a constant up-and-down movement amongst the residuals is noted, then it would depict that the disturbances are uncorrelated (Gujarati, 2003).

Figure 9 Residual Plot



In Figure 9, it can be observed that a constant up-and-down movement exists amongst the residuals. Thus, it can be inferred that the disturbances are uncorrelated.

The formal method applied in detecting autocorrelation is the Wooldridge test for autocorrelation in panel data. The null hypothesis for this test is that there is no first-order autocorrelation in the disturbances. The decision rule for the test is that, if the p-value of the computed test statistic is less than the 5% (or 0.05) significance level of the study, then the null hypothesis is rejected that there is no first-order autocorrelation in the disturbances (Gujarati, 2003). The result is a test statistic of 44.2023 with p-value of 1.0911e-007. Since the p-value is below the 5% (or 0.05) significance level of the study, the null hypothesis of no first-order autocorrelation in the disturbances is rejected.

However, the Wooldridge test only tests for autocorrelation in the first order (i.e., it checks whether the disturbance in the current time period is correlated with the disturbance term in the previous time period). It is quite possible that ε_{it} is correlated with its immediate past value, but uncorrelated with its values several periods in the past. Thus, the value of autocorrelation will dissipate as testing is conducted in to the distant past. On this basis, it is common practice to invoke the stationarity test in assessing the presence of autocorrelation in the disturbances.

The ADF test is designed to account for correlated errors, thus, the potential issue of autocorrelation or correlated errors is addressed with the application of the ADF test for unit root (Gujarati, 2003). Since the results of the test confirm stationarity of the data, it simultaneously confirms that the errors in the model are not correlated.

4.2.6 Test for Cross-Sectional Dependence

According to Baltagi, Feng, and Kao (2012), cross-sectional dependence or interdependence is described as the interaction between cross-sectional units (e.g., households, firms, schools, states, countries, etc.) to the extent that they affect each other‟s outcomes. Behavioural interaction between cross-sectional units can be the root cause of cross-sectional interdependence. Cross-sectional interdependence can also be due to unobservable common factors, or typical macroeconomic shocks. With respect to this study, cross-sectional interdependence can be traced to the behavioural interaction between countries. A classic example of such interaction is the harmonisation of agricultural, investment, and trade policies by African countries, resulting from the Maputo convention of 2003.

The study tests for cross-sectional interdependence using the Pesaran cross-sectional dependence (CD) test. The test is based on a scaled average of the pairwise correlation coefficients between the residuals of each individual unit. Thus, indirectly, spatial autocorrelation is simultaneously assessed. This is reasonable as panel data have time as well as space dimensions. The null hypothesis for this test is that there is no cross-sectional dependence. The decision rule for the test is that, if the p-value of the computed z statistic is less than the 5% (or 0.05) significance level of the study, then the null hypothesis is rejected that there is no cross-sectional dependence (Baltagi, et al., 2012). The result is a z statistic of 5.864475 with a p-value of 4.50556e-009. Since the p-value is below the 5% (0.05) significance level of the study, the null hypothesis of no cross-sectional dependence is rejected.

The CNLRM assumption as it applies to cross-sectional dependence can be too general an assumption to be of significant practical use. First, given the nature of the study, interaction amongst the cross-sections is inevitable. Second, caution must be exercised not to overreact, because even if the estimators of the disturbances i.e., the residuals are cross-sectionally interdependent, the actual disturbances can be independent. This is because, as the sample size increases indefinitely, the residuals tend to converge to their true values i.e., the actual disturbances (Gujarati, 2003). Once again, special reference is made to the plot of residuals in Figure 9, and the ADF test, both of which confirm that the disturbances are indeed uncorrelated.

4.2.7 Test for Heteroscedasticity

The CNLRM assumes that given the values of the regressors, the variance of the error term, ε_{it} must be equal to some constant number, σ^2 (i.e., V (ε_{it}) = σ^2) for all observations, and if this assumption is tenable, then there is homoscedasticity. On the other hand, if the error term, ε_{it} does not have the same variance, σ^2 for each observation, then there is heteroscedasticity.

Reverting to the augmented regression model, though it is assumed that investments correlate positively with agricultural output, it is possible that for higher (values of) investments, the relation is less precise. That is, the law of diminishing marginal returns takes effect, and as such, the error term in the model would not only have unequal variance for each observation, it would also have more variance with larger investments than with smaller. Therefore, it can be inferred that though unbiased and consistent, the estimates do not have minimum variance (or are not efficient), and the variance of the error depends on investments. This statement violates a necessary condition for the CNLRM - unbiased estimates with minimum variance or unbiased and efficient estimates.

The study tests for the presence of heteroscedatic errors using the Wald test for heteroscedasticity. The null hypothesis for this test is that the observations have a common error variance. The decision rule for the test is that, if the p-value of the computed χ^2 statistic is less than the 5% (or 0.05) significance level of the study, then the null hypothesis is rejected that the observations have a common error variance (Gujarati, 2003). The result is a χ^2 value of 1565.35 with p-value of 5.45614e-306. Since the p-value is below the 5% significance level of the study, the null hypothesis that the observations have a common error variance is rejected.

According to Mankiw (1990), most economic analyses of panel data involving heterogeneous units are bound to present issues relating to heteroscedasticity. Therefore, heteroscedasticity is not a substantial enough reason to discard what appears to be a good model; the impact of violating the assumption of homoscedasticity is a matter of degree, increasing as heteroscedasticity increases, and vice versa. Since the data for this study are pooled involving a heterogeneity of countries differing in size and capacity, there is the tendency for the variables to be of varying orders of magnitude. As a result, a priori, one can expect heteroscedasticity in the error variance.

4.2.8 Test for Multicollinearity

According to Gujarati (2003), collinearity refers to a situation in which there is an *exact* linear association between two explanatory variables. When there is more than one exact linear relationship among the variables, the term, Multicollinearity is used. In other words, when two explanatory variables are so highly correlated that they explain each other (to the point where one variable can predict the outcome of the other), then there is a situation of collinearity. When more than two explanatory variables in a multiple regression model are highly correlated, the term, multicollinearity is used.

The consequences of multicollinearity are three-folds. In the case of perfect multicollinearity (i.e., the dummy variable trap) the regression coefficients of the explanatory variables are indeterminate, and their standard errors are not defined (or are infinite). If there is high but imperfect multicollinearity, estimation of the regression coefficients is possible, but their standard errors tend to be large, which means the coefficients cannot be estimated with great precision or accuracy. Other levels of multicollinearity increase the standard errors of the coefficients of the individual variables, thereby making it less likely for variables that are economically and statistically significant to be significant.

Table 11 Test for Multicollinearity

Belsley-Kuh-Welsch (BKW) Collinearity Diagnostics:
Condition Index (cond)
1.000
7.161
10.620
12.136
15.100
17.824
23.548
47.043
99.493
146.217

Source: Author's Compilation from the Gretl output of Multicollinearity Test.

Table 11 reports the output of the Belsley-Kuh-Welsch test for collinearity of variables DPRI, DPGE, DPRD, FPRI, FPUI, CRA, AP, EXRT, and TROP. According to the BKW test, cond ≥ 30 indicates strong multicollinearity, while cond between 10 and 30 indicates moderately strong multicollinearity. Count of condition indices $\geq 30 = 3$, while count of condition indices $\geq 10 = 8$. Parameter estimates whose variance is mostly associated with cond ≥ 30 include: constant, DPRI, DPRD, and AP. Parameter estimates whose variance is mostly associated with cond ≥ 10 include: constant, DPRI, DPGE, DPRD, FPRI, FPUI, CRA, AP, EXRT, and TROP.

According to Kmenta (1986), multicollinearity is a feature of the sample selected for test work, and not the entire population; in other words, multicollinearity is essentially a data deficiency problem. Therefore, the meaningful analysis on multicollinearity is not its presence or absence, but rather, its degree in any given sample or data set. Consider that even if the regressor variables are not linearly related in the population, they may be related in the particular sample at hand; that is, while the population regression function (PRF) may have regressors that have a separate or independent influence on the dependent variable, the case may be that in any given sample that is used to test the PRF, some or all of the regressor variables are so highly collinear that one cannot isolate their individual influence on the dependent variable. Thus, multicollinearity is in essence a sampling regression phenomenon with the primary concern being the degree to which it exists. Given that this study employs variables that are highly interrelated, there is bound to be a moderate to strong degree of multicollinearity.

4.2.9 Test for Normality of Disturbances

The normality assumption of the stochastic (or random) ε_{it} requires that the disturbances are independently and identically distributed with zero mean and constant (or homoscedastic) variance [i.e., $\varepsilon_{it} \sim N(0, \sigma^2)$]. According to Gujarati (2003), the Normality criterion is necessary in order to establish the following: (i) the estimators of the regression model follow the normal distribution; (ii) the t, F, and chi-square statistics follow the t, F, and chi-square distributions; and (iii) one can use the usual t and F test procedures to test various statistical hypotheses, draw inferences, and make predictions regardless of sample size.

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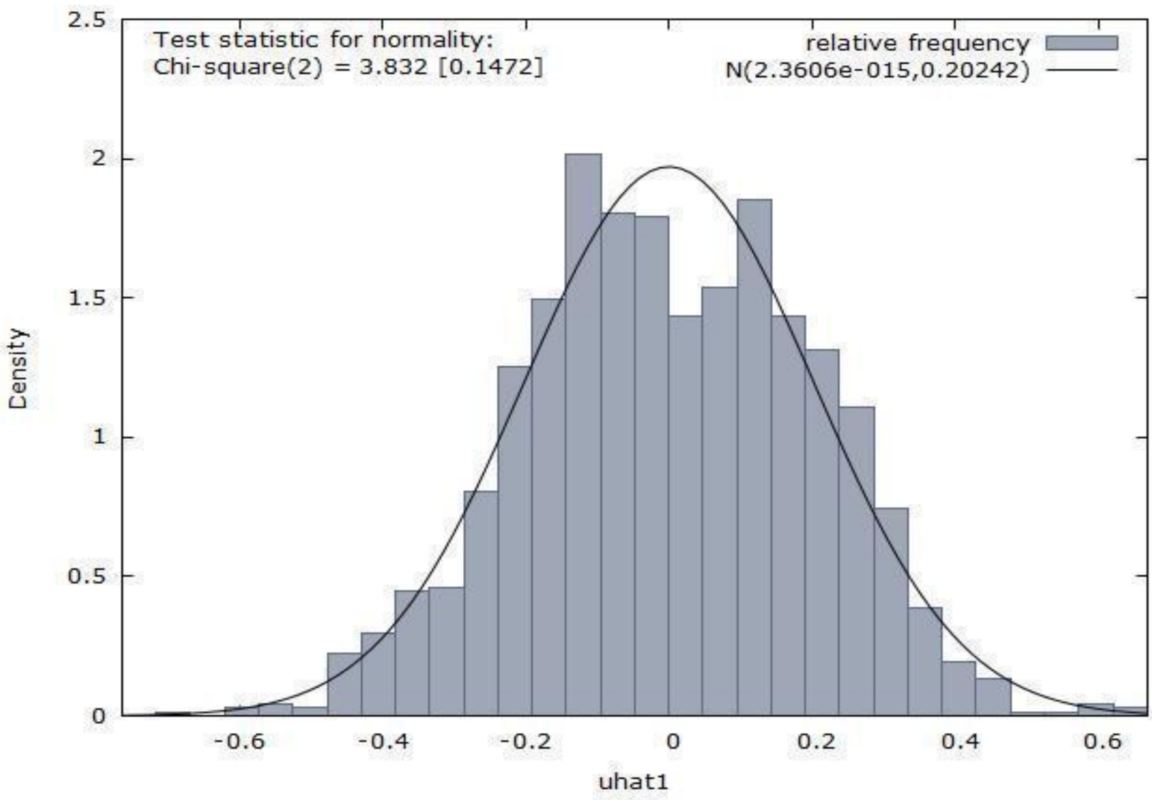
There are a few consequences associated with the violation of the normality assumption as it does not affect the unbias and efficient properties of the estimators. However, if the error terms are not normal, the standard errors of the estimates won‟t be reliable, which means that the confidence intervals would be too wide or narrow. The end result could be the acceptance of a false hypothesis or rejection of a true hypothesis.

Although there are several normality tests that can be performed to validate this assumption, the study tests for the normality of the disturbances using the histogram of residuals and the chi-square test of normality. The histogram of residuals is illustrated in Figure 10. The histogram of residuals is an effective graphical technique of showing normality of the residuals. When a set of approximately normal residuals are graphed via a histogram, it shows a bell peak and most data within + or – three standard deviations of the mean (Gujarati, 2003).

Figure 10 Histogram of Residuals



In Figure 10, it can be observed that the histogram is in the shape of a bell peak, and most of the data are within + or – three standard deviations of the residual mean, 0. Thus, it can be inferred that the disturbances are normally distributed.

The null hypothesis for the chi-square test of normality is that the disturbances are normally distributed. The decision rule for the test is that, if the p-value of the computed χ^2 statistic is less than the 5% (or 0.05) significance level of the study, then the null hypothesis is rejected that the disturbances are normally distributed (Gujarati, 2003). The result is a χ^2 value of 3.832 with p-value 0.14717. Since the p-value is above the 5% significance level of the study, the null hypothesis that the disturbances are normally distributed is not rejected, rather, it is accepted.

4.2.10 Fixed-Effects Model Analyses

The estimates obtained for the variables in the Fixed-Effects model have been incorporated in to the final augmented regression model **(5)** below. The regression results provide numerical measurement between the dependent variable and the explanatory variables. In other words, the regression results show the numerical sensitivity of agricultural output with respect to changes in investments in agriculture.

^AOI = -1.94*** + 0.245***DPRI + 0.00152 DPGE + 0.0757***DPRD + 0.00425***FPRI

(0.218) (0.00944) (0.00170) (0.00930) (0.00113)

+ 0.00154 FPUI + 0.0217***CRA + 0.0674***AP - 0.0273***EXRT + 0.0135*TROP

(0.00128) (0.00313) (0.0250) (0.00519) (0.00815)

n = 1404, R-squared = 0.727, F statistic = 82.1309, P-value (F) = 0.0000

(Standard errors in parentheses).

*** Implies statistical significance at 1%, ** at 5%, and * at 10%.

Source: Author’s Compilation from the Gretl output of Fixed-Effects Model.

The test for the joint or overall statistical significance of the estimated multiple regression model involves comparing the F statistic to the critical F value at the 5% (or 0.05) level of significance, otherwise referred to as the p-value of F. The null hypothesis for this test is that the estimated regression is not statistically significant. The decision rule for the test is that, if the F statistic is greater than the p-value of F, then the null hypothesis is rejected that the estimated regression is not statistically significant (Gujarati, 2003). The result is an F statistic of 82.1309 with P-value (F) of 0.0000. Since the F statistic is above the P-value (F), the null hypothesis that the estimated regression is not statistically significant is rejected. The results also reveal an R-squared of 0.727 (or 72.7%). The R-squared of 72.7% indicates that 72.7% of the total variation in the dependent variable (AOI) is explained by the independent variables. In summary, the results show that the totality of the model is significant, and that it has a high goodness of fit.

Table 12 A priori Expectations

S/N	Description	Coefficient	Expectation	Result	Coefficient Value
1	Constant	β_0	$\beta_0>0$	$\beta_0<0$	-1.94***
2	DPRI	β_1	$\beta_1>0$	$\beta_1>0$	0.245***
3	DPGE	β_2	$\beta_2>0$	$\beta_2>0$	0.00152
4	DPRD	β_3	$\beta_3>0$	$\beta_3>0$	0.0757***
5	FPRI	β_4	$\beta_4>0$	$\beta_4>0$	0.00425***
6	FPUI	β_5	$\beta_5>0$	$\beta_5>0$	0.00154
7	CRA	β_6	$\beta_6>0$	$\beta_6>0$	0.0217***
8	AP	β_7	$\beta_7>0$	$\beta_7>0$	0.0674***
9	EXRT	β_8	$\beta_8<0$	$\beta_8< 0$	-0.0273***
10	TROP	β_9	$\beta_9>0$	$\beta_9>0$	0.0135*
11	Sum of Elasticities	$\beta_1 + \beta_2 + \ldots + \beta_9$	$\beta_1+\beta_2+\ldots+\beta_9\neq1$	$\beta_1+\beta_2+\ldots+\beta_9\neq1$	0.403758

*** Implies statistical significance at 1%, ** at 5%, and * at 10%. *Source*: Author's Compilation.

The **Constant** of the model, β_0, though significant, did not yield the hypothesised expectation. The sign of β_0 was expected to be positive, but it turned out to be negative. This shows that Africa's enormous natural and human resources are grossly underutilised in influencing output in the agricultural sector, holding all other variables as specified in the model constant. The independent focus variables, DPRI, DPGE, DPRD, FPRI, FPUI, and independent control variables, CRA, AP, EXRT, TROP, with coefficients β_1, β_2, β_3, β_4, β_5, and β_6, β_7, β_8, β_9, respectively, all yielded the hypothesised expectations. While the sign of β_8 was expected to be negative, the signs of the other aforementioned coefficients were expected to be positive, and they all turned out to be as such for the same reasons expressed in section 3.3.1 of the study. The **Sum of Elasticities** of the model, i.e., $\beta_1 + \beta_2 + \ldots + \beta_9$, yielded the hypothesised expectation. The value was expected to not equal 1, and it turned out to be less than 1, implying that the agricultural output function exhibits decreasing returns to scale.

DPRI

The DPRI variable with coefficient of 0.245*** indicates a positive and significant relationship between domestic private investments in agriculture and agricultural output in Africa. This implies that, for every 1% increase in DPRI, the impact on AOI is an increase of 0.245%, at the 1% level of significance. This is consistent with the findings of Baba, Saini, Sharma, and Thakur (2010) and Bathla (2014).

The coefficient of this variable shows that domestic private investment is the most impactful category of investment in African agriculture. This is extremely positive result for both the African Union and indigenous farmers in Africa. One of the key objectives of the Maputo convention is to execute its agricultural growth drives through domestic private investors in African agriculture. This result therefore, substantiates the agricultural growth drives of the African Union, as well as expands the development benefits of indigenous farmers from investments in agriculture. FPRI may very well account for the largest share of agricultural investment flows in Africa, but DPRI is the most impactful. This provides the panacea for African governments to realize goals (i) and (ii) of the SDGs.

DPGE

The coefficient of variable DPGE is 0.00152, indicating a positive, but insignificant relationship between domestic public investments in terms of general government expenditure on agriculture and agricultural output in Africa. This implies that as DPGE increases by 1%, an increase of 0.00152%, though statistically insignificant, is expected on AOI. This contradicts the findings of Bathla (2017) and Sinha (2017), which reveal a positive and significant impact of DPGE on agriculture in India.

Notwithstanding, the result of this study implies that DPGE in Africa does not produce the desired impact on agricultural output. This could be due to inefficiency in the utilisation of government funds allocated to agriculture, or the composition and quality of government expenditure on agriculture. It could also be due to the prevalent corruption that has eaten deep in to the roots of governance in Africa. It is critical therefore, that all three suppositions are thoroughly investigated in order to get improved productivity from the DPGE investment category. This is because given the magnitude of agricultural development in Africa, there are certain projects that are so big/costly, that only the central governments have the capacity to undertake. Examples of such projects include the development of roads network and the energy industry.

DPRD

The parameter estimate attached to the DPRD variable is 0.0757***, indicating a positive and significant relationship between domestic public investments in terms of public spending on agricultural R&D and agricultural output in Africa. This implies that, as DPRD increases by 1%, the impact on AOI is an increase of 0.0757%, at the 1% level of significance. This is in line with the findings of Bathla, Joshi, and Kumar (2017) and Mustapha and Enilolobo (2019).

The coefficient of this variable reveals that domestic public investment in agricultural R&D is the second most impactful category of investment in African agriculture. The DPRD variable is the one variable that has the ability to directly impact the productivity of the other investment variables, particularly if investments in R&D yield innovative results; thus, the significance of African governments investing in agricultural R&D can never be overemphasized.

FPRI

The FPRI variable with coefficient of 0.00425*** indicates a positive and significant relationship between foreign private investments in agriculture and agricultural output in Africa. This implies that, for every 1% increase in FPRI, the impact on AOI is an increase of 0.00425%, at the 1% level of significance. This contradicts the findings of Epaphra and Mwakalasya (2017), which reveal a positive, but insignificant impact of FPRI on agriculture in Tanzania.

The findings in this study is that from 1980 to 2018, FPRI accounted for the largest share of agricultural investment flows in Africa. Despite the heavy presence of FPRI in African agriculture, it is only the third most impactful category of investment. However, this should not discourage the pursuit of FPRI, particularly if FPRI inflows and real GDP growth rate are positively correlated. Rather, African agriculturalists should find better ways of channelling FPRI in agriculture to achieve optimum results.

FPUI

The coefficient of variable FPUI is 0.00154, indicating a positive, but insignificant relationship between foreign public investments in agriculture and agricultural output in Africa. This implies that as FPUI increases by 1%, an increase of 0.00154%, though statistically insignificant, is expected on AOI. This does not conform with the findings of Alabi (2014) and Barkat and Alsamara (2019), which reveal a positive and significant impact of FPUI on agriculture in Africa.

Notwithstanding, the result of this study implies that FPUI (or aid) in Africa does not produce the desired impact on agricultural output. Because most aid issued to Africa are transmitted through government, the result of this study could be due to inefficiency in the utilisation of aid funds allocated to agriculture, or the prevalent corruption that plagues governance in Africa. It could also be due to the composition and quality of donor aid issued to African agriculture. Another reason could be associated with the volume of agricultural aid, considering that from 1980 to 2018, FPUI accounted for the least share of agricultural investment flows in Africa. That being said, the strong correlation between aid dependency, corruption, and the nature of government structures in many African countries is well chronicled (Boone, 1995; Whitaker, 2006; Knack, 2000; Moyo, 2010; Bauer, 1971; Friedman, 1958), leading to the conclusion that in the long run, systemic aid is bad for Africa. Therefore, emphasis on the more productive investment categories may be better for the development of African agriculture.

CRA

The parameter estimate attached to the CRA variable is 0.0217***, indicating a positive and significant relationship between agricultural credit and agricultural output in Africa. This implies that, as CRA increases by 1%, the impact on AOI is an increase of 0.0217%, at the 1% level of significance. While this conforms with the findings of Sogo-Temi and Olubiyo (2004), Rehman, Chandio, Hussain, and Jingdong (2017), Obilor (2013), and Abedullah, Mahmood, and Kouser (2009), it contradicts the findings of Ogwumike and Ozughalu (2014), who reported a positive but insignificant impact of credit incentives on agricultural sector performance in Nigeria.

Despite the conflicting results, what is undeniable in this study is that CRA is positively correlated with DPRI and AOI. This reveals a degree of effective credit policy implementation and administration that if improved on, will go a long way in promoting domestic private sector participation in African agriculture, as well as enable Africa achieve goals (i) and (ii) of the SDGs.

AP

The AP variable with coefficient of 0.0674*** indicates a positive and significant relationship between agricultural policy and agricultural output in Africa. This implies that, for every 1% increase in AP, the impact on AOI is an increase of 0.0674%, at the 1% level of significance. Though this is consistent with the findings of Ode-Omenka (2018), it is not in line with the findings of Ogwumike and Ozughalu (2014), who reported a positive but insignificant impact of institutional reform on agricultural sector performance in Nigeria.

The coefficient of the AP control variable shows that it is both the most impactful control variable and the third most impactful independent variable in this study. It is also positively correlated with DPRI, DPGE (although statistically insignificant), DPRD, FPRI, FPUI (although statistically insignificant), and AOI. These results reveal a good degree of effective agricultural policy formulation and implementation in Africa that if improved on, will go a long way in reversing the narratives of African agriculture.

EXRT

The coefficient of variable EXRT is -0.0273***, indicating a significant, albeit inverse relationship between exchange rate and agricultural output in Africa. This implies that as EXRT increases by 1%, a decrease of -0.0273% is expected on AOI, at the 1% level of significance. This is not consistent with the findings of Anowor, Ukweni, and Martins (2013) and Joel and Glory (2018). While the former reported a positive but insignificant impact of exchange rate on agricultural sector performance in Nigeria, the later reported a positive and significant impact in Cameroon.

The divergent relationship between exchange rate and agricultural output in African agriculture is usually expected to produce a negative sign for the coefficient of the exchange rate variable; thus, the negative correlation between EXRT, DPRI, DPGE (although statistically insignificant), DPRD, FRPI, FPUI (although statistically insignificant), and AOI meets expectation. The interpretation of this result is that the exchange rate level in African agriculture is generally low. While the advantage of a low exchange rate (i.e., depreciation or devaluation of the national currency) on agricultural output is that, it attracts foreign investments, which leads to higher output levels, the drawback is that, it reduces the capacity of stakeholders to invest in the imports of agricultural inputs, which in turn leads to lower output levels. Many countries in Africa face a dilemma in the level of exchange rate to maintain, but the issue is not so much the exact choice of exchange rate level, but rather, making a decisive choice, and then maintaining responsible fiscal and monetary policies to manage the drawbacks of the choice made.

TROP

The parameter estimate attached to the TROP variable is 0.0135*, indicating a positive and significant relationship between trade openness and agricultural output in Africa. This implies that, as TROP increases by 1%, the impact on AOI is an increase of 0.0135%, at the 10% level of significance. This is in line with the findings of De Silva, Malaga, and Johnson (2013), Hassine, Robichaud, and Decaluwe (2010), and Verter (2016).

Trade liberalization attracts foreign investors, as well as expands opportunity for trade. Over the years, trade liberalization has emerged as a significant tool for foreign investors to tap in to the agricultural value chain of African countries, as well as enable African countries participate in the global trading space. Thus, it is customary that TROP is positively correlated with FPRI, FPUI (although statistically insignificant), and AOI. However, at 10% level of statistical significance, TROP in Africa needs improvement, particularly in the area of agricultural export expansion. This will help diversify mineral-dependent and mono-crop export economies.

4.3 Direction of causality between the investment categories in agriculture and agricultural output in Africa.

This section addresses the third specific research objective, which is to determine the direction of causality between the investment categories in agriculture and agricultural output in Africa.

The Pairwise Granger Causality Test was applied to determine the direction of causality between the investment categories in agriculture and agricultural output in Africa. Table 13 reports the output of the test.

Table 13 Panel Pairwise Granger Causality Test

Null Hypothesis	Obs.	F-statistic	P-value (F)	Decision
DPRI does not Granger cause AOI	1,402	9.9529	0.0001	Reject
AOI does not Granger cause DPRI	1,402	0.84930	0.4279	Accept
DPGE does not Granger cause AOI	1,402	0.72645	0.4838	Accept
AOI does not Granger cause DPGE	1,402	5.9123	0.0028	Reject
DPRD does not Granger cause AOI	1,402	5.7396	0.0033	Reject
AOI does not Granger cause DPRD	1,402	0.097666	0.9070	Accept
FPRI does not Granger cause AOI	1,402	4.2227	0.0148	Reject
AOI does not Granger cause FPRI	1,402	0.79303	0.4527	Accept
FPUI does not Granger cause AOI	1,402	7.1354	0.0008	Reject
AOI does not Granger cause FPUI	1,402	1.7907	0.1672	Accept

Source: Author's Compilation from the Gretl output of Pairwise Granger Causality Test.

The Granger causality test shows a directional causal relationship between DPRI and AOI, DPGE and AOI, DPRD and AOI, FPRI and AOI, and FPUI and AOI. The results indicate that the direction of causality is from DPRI to AOI, AOI to DPGE, DPRD to AOI, FPRI to AOI, and FPUI to AOI, since the estimated F values are significant at the 5% (or 0.05) level. On the other hand, there is no reverse causation from AOI to DPRI, DPGE to AOI, AOI to DPRD, AOI to FPRI, and AOI to FPUI, since the F values are statistically insignificant.

The Granger causality test also reveals the following: DPGE causes FPUI, with F-statistic of 3.6588 and P-value (F) of 0.0260; DPRD causes DPRI, with F-statistic of 10.231 and P-value (F) of 0.0000, and lastly; FPRI causes DPGE, DPRD, and FPUI, with F-statistics of 3.1337, 10.309, and 4.4305, and P-values (F) of 0.0439, 0.0000, and 0.0002, respectively.

4.4 Answers to the Research Questions

In section 1.3 of this study three inquiries were launched as to (i) the nature of the patterns of investments in agriculture in Africa, (ii) the extent to which the categories of investments in agriculture impact agricultural output in Africa, and (iii) the direction of causality between the investment categories in agriculture and agricultural output in Africa.

To respond to these inquiries, the researcher in section 1.4 set out to (i) examine the patterns of investments in agriculture in Africa, (ii) estimate the impact of the categories of investments in agriculture on agricultural output in Africa, and (iii) determine the direction of causality between the investment categories in agriculture and agricultural output in Africa.

Based on the tests carried out and analyses documented in sections 4.1, 4.2, and 4.3, the formulated null hypotheses in section 1.5 that (i) domestic private investments are the least source of investments in agriculture in Africa, followed by domestic public investments, foreign public investments, and foreign private investments, (ii) the categories of investments in agriculture do not have a significant positive impact on agricultural output in Africa, and

(iii) there is absence of causality between the investment categories in agriculture and agricultural output in Africa, are hereby rejected.

However, with respect to this study, rejection of the null hypotheses does not imply acceptance of the alternative hypotheses that (i) domestic private investments are the largest source of investments in agriculture in Africa, followed by domestic public investments, foreign public investments, and foreign private investments, (ii) the categories of investments in agriculture have a significant positive impact on agricultural output in Africa, and (iii) there is unidirectional causality between the investment categories in agriculture and agricultural output in Africa, with causality from the investment categories to agricultural output.

Rather, the following conclusions are drawn:

(i) Foreign private investments (FPRI) are the largest source of investments in agriculture in Africa, followed by domestic private investments (DPRI), domestic public investments (i.e., domestic public investments in terms of general government expenditure on agriculture {DPGE} plus domestic public investments in terms of public spending on agricultural R&D {DPRD}), and foreign public investments (FPUI).

(ii) With the exception of DPGE and FPUI, which are positively correlated with agricultural output, but statistically insignificant, the categories of investments in agriculture have a significant positive impact on agricultural output in Africa, with the order of significance being DPRI, DPRD, and FPRI.

(iii) There is unidirectional causality between the investment categories in agriculture and agricultural output in Africa, with causality from investment category to agricultural output in the cases of DPRI, DPRD, FPRI, and FPUI, but the other way round in the case of DPGE.

CHAPTER FIVE

SUMMARY, CONCLUSION, AND POLICY RECOMMENDATIONS

5.1 Summary

The Food and Agricultural Organisation (FAO) of the United Nations categorises investments in agriculture as domestic private, domestic public, foreign private, and foreign public investments (FAO, 2012). The main objective of this study is to estimate the impact of the categories of investments in agriculture on agricultural output in Africa. The patterns of investments in agriculture in Africa, and the direction of causality between the investment categories in agriculture and agricultural output in Africa were also examined. Agricultural output index, agricultural gross fixed capital formation, general government expenditure on agriculture, public spending on agricultural research and development (R&D), foreign direct investments, and development flows to agriculture are prominent variables of the study. The data sources of these variables include the FAO of the United Nations, the International Food Policy Research Institute (IFPRI), and the United Nations Conference on Trade and Development (UNCTAD).

The agricultural output model was constructed using (secondary) annual balanced panel data on 36 member-countries of the African Union covering the period of 1980 - 2018. The study employed the Augmented Dickey-Fuller (ADF) test for unit root to verify stationarity of the data. Three panel data models were evaluated for the study, namely, Pooled Ordinary Least Squares (Pooled OLS), Fixed-Effects (FE), and Random-Effects (RE) models. For optimality, panel model diagnostics, the Breusch-Pagan LM test, and the Hausman specification test were conducted to choose between the aforementioned models, with the FE model emerging superior. The study also employed the histogram of residuals and the chi-square test of normality to verify normal distribution of the disturbances.

5.2 Conclusion

The results reveal that the variables in the model are stationary at level and the disturbances are normally distributed. The results also reveal that foreign private investments (FPRI) are the largest source of investments in agriculture in Africa, followed by domestic private investments (DPRI), domestic public investments (i.e., domestic public investments in terms of general government expenditure on agriculture {DPGE} plus domestic public investments in terms of public spending on agricultural

R&D {DPRD}), and foreign public investments (FPUI). Furthermore, with the exception of DPGE and FPUI, which are positively correlated with agricultural output, but statistically insignificant, the categories of investments in agriculture have a significant positive impact on agricultural output in Africa, with the order of significance being DPRI, DPRD, and FPRI. Finally, there is unidirectional causality between the investment categories in agriculture and agricultural output in Africa, with causality from investment category to agricultural output in the cases of DPRI, DPRD, FPRI, and FPUI, but the other way round in the case of DPGE.

5.3 Policy Recommendations

Based on the findings documented in section 5.2, the following policies are recommended on the significant variables of the study:

- ***Domestic private investments (DPRI) -*** Agricultural development initiatives in Africa should be geared towards increasing domestic private sector participation in agriculture by providing domestic private investors with (i) credit facilities or grants to secure farm land and modern agricultural machinery and equipment, (ii) adequate government support, particularly in the areas of energy, transport, storage, and irrigation infrastructure, and (iii) sustainable demand for their products, particularly by agro-allied processors and manufacturers.

- ***Domestic public investments in terms of public spending on agricultural research and development (DPRD) -*** Agricultural research and development (R&D) policy framework should be designed to focus on agricultural science and technology, particularly to (i) improve storage facilities, (ii) control soil erosion, (iii) eradicate insects, pests, and plant and animal diseases, (iv) develop high-yielding seeds and fertilizers, and (v) create productivity-enhancing technologies.

- ***Foreign private investments (FPRI) –*** An environment that is conducive for foreign investment should be created and sustained across Africa. This implies creating an environment that reduces investment risks that result in capital flight or disinvestment from interested foreign private investors. It also implies that the African governments must maintain political stability and minimise conflicts in order to encourage foreign private investors. Lastly, it implies that there must be property rights enforcement and the existence of a legal system that guarantees fairness and justice.

- ***Credit to agriculture (CRA) -*** Considering the long gestation period of agricultural production and profitability of farm production, the banking system in Africa should issue long-term and low interest credit facilities to farmers to encourage investments in agriculture. Additionally, the securing of farm land and farm technologies should be of foremost consideration in the design of credit strategies.

- ***Agricultural policy (AP) -*** There should be improved dialogue between government and the private sector to come up with effective policies for trade, agriculture, and investment that support the continental agricultural agenda. Agricultural policy framework should include (i) change in the existing land ownership/tenure arrangements to improve land accessibility (ii) tax incentives for producers, (iii) substantial expansion of agricultural education, (iv) prevention of farm land encroachment, (v) better implementation and monitoring on the local levels, signed on policies at the national and regional levels, and (vi) improved accountability and reliable measurement of progress on agricultural targets.

- ***Exchange rate (EXRT) -*** With the low exchange rate level that many countries in Africa maintain, foreign investors should be made to provide the agricultural inputs, such as machine equipment and raw materials for industry that consume scarce foreign exchange reserves of African countries.

- ***Trade openness (TROP) -*** African countries should continue to enhance the investment climate to attract foreign investors in agriculture, but more importantly, expand the production of agricultural export commodities, with a view to diversify mineral-dependent and mono-crop export economies.

Though domestic public investments in terms of general government expenditure on agriculture (DPGE) turned out to be statistically insignificant, the role of the central governments in African agriculture cannot be relegated given the magnitude of agricultural development still required on the continent. Therefore, African governments are still encouraged to critically assess the different stages of the agricultural value chain in order to invest in the areas that need support. Special emphasis should be on capital deepening in high yielding areas of overhead infrastructure such as energy, irrigation, transport, and storage systems. An important caveat to mention is that the transparency and regulatory integrity of public spending are fundamental to any public expenditure agenda.

According to Moyo (2010), investment intentions of foreign public investors in Africa are usually not geared towards permanent solutions to address the unique economic challenges faced by this group of less developed countries (LDCs). Dividing aid in to (i) emergency aid,

(ii) charitable aid, and (iii) systemic aid, Moyo (2010) opined that while emergency and charitable aid are acceptable, African governments should shy away from systemic aid, which is believed to foster corruption and dependency. Therefore, despite the statistically insignificance of foreign public investments (FPUI) in African agriculture, African governments are still encouraged to be open to emergency and charitable aid for agricultural related activities and ensure that such aid receipts are effectively and efficiently utilised, but should avoid soliciting for systemic aid.

5.4 Suggestions for Future Research

The 10% agricultural spending target of the Maputo convention would be a blunt instrument without efficient allocation to key areas of the statistically significant categories of investments (i.e., DPRI, DPRD, and FPRI). The daunting question is which area of agriculture spending for each of these investment categories is most fundamental for sustainable agricultural growth? Future research will attempt to answer this question, as well as consider the impact of past values of agricultural output on the impact of investments on agricultural output in the current period. This type of study will require a dynamic panel model specified and estimated within a structural equation modelling (SEM) system.

5.5 Contributions to Knowledge

Though seven of the nine regressor variables (i.e., DPRI, DPRD, FPRI, CRA, AP, EXRT, and TROP) of the study are significant in impacting agricultural sector performance, their relatively low coefficient values indicate that to date, investment in agriculture remains relatively low in spite the efforts made by the private and public sectors. The agricultural potential in Africa is still under-exploited, but offers considerable growth opportunities of facilitating a smooth integrated development of the agricultural sector across the region, if the above-mentioned policy recommendations are implemented.

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APPENDICES

Table 8 Results of Pooled OLS Model

Variable	Coefficient	Std. Error	t-ratio	p-value
Constant	3.61356	0.134412	26.88	1.32e-128***
ln DPRI	0.0508737	0.00547504	9.292	5.64e-020***
ln DPGE	-0.00302235	0.00227559	-1.328	0.1843
ln DPRD	-0.0159605	0.00641909	-2.486	0.0130**
ln FPRI	0.0116688	0.00154863	7.535	8.75e-014***
ln FPUI	0.0188114	0.00144175	13.05	8.52e-037***
ln CRA	-0.00353589	0.00122285	-2.892	0.0039***
ln AP	-0.0886576	0.0136976	-6.472	1.33e-010***
ln EXRT	-0.0279900	0.00327434	-8.548	3.23e-017***
ln TROP	-0.00672886	0.0105473	-0.6380	0.5236
Mean dependent var	4.417341	S.D. dependent var	0.385961	
Sum squared resid	128.1852	S.E. of regression	0.303241	
R-squared	0.386672	Adjusted R-squared	0.382712	
F(9, 1394)	97.64953	P-value (F)	3.0e-141	
Log-likelihood	-311.8792	Akaike criterion	643.7585	
Schwarz criterion	696.2293	Hannan-Quinn	663.3704	
Rho	0.908111	Durbin-Watson	0.158939	

*** Implies statistical significance at 1%, ** at 5%, and * at 10%.

Source: Author's Compilation from the Gretl output of Pooled OLS Model.

Table 10 Results of Random-Effects Model

Variable	Coefficient	Std. Error	z-stat	p-value
Constant	0.872677	0.195108	4.473	7.72e-06***
ln DPRI	0.157327	0.00847339	18.57	5.92e-077***
ln DPGE	-0.00105387	0.00194832	-0.5409	0.5886
ln DPRD	0.0282642	0.00873490	3.236	0.0012***
ln FPRI	0.00666699	0.00130226	5.120	3.06e-07***
ln FPUI	0.0105802	0.00137638	7.687	1.51e-014***
ln CRA	0.000486203	0.00212932	0.2283	0.8194
ln AP	-0.0505060	0.0204455	-2.470	0.0135**
ln EXRT	-0.0463864	0.00457783	-10.13	3.95e-024***
ln TROP	0.00476573	0.00934660	0.5099	0.6101
Mean dependent var	4.417341	S.D. dependent var	0.385961	
Sum squared resid	191.7939	S.E. of regression	0.370792	
Log-likelihood	-594.7470	Akaike criterion	1209.494	
Schwarz criterion	1261.965	Hannan-Quinn	1229.106	
Rho	0.876465	Durbin-Watson	0.233658	

*** Implies statistical significance at 1%, ** at 5%, and * at 10%.

Source: Author's Compilation from the Gretl output of Random-Effects Model.

VAR LAG Selection

VAR system, maximum lag order 2

The asterisks below indicate the best (that is, minimized) values of the respective information criteria, AIC = Akaike criterion, BIC = Schwarz Bayesian criterion, and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	-16566.21423		23.803444	24.252430*	23.971273*
2	-16392.07734	0.00000	23.697685*	24.520827	24.005372

Source: Gretl output of Panel Vector Auto Regressive (VAR) test.

Coefficient Covariance Matrix

Const	DPRI	DPGE	DPRD	FPRI	
0.0476557	-0.00129333	-6.96657e-005	-0.000925839	3.23154e-005	const
	8.90549e-005	-5.62132e-007	-2.20286e-005	-1.09098e-006	DPRI
		2.87995e-006	5.14667e-007	-1.20502e-007	DPGE
			8.64632e-005	-1.50255e-006	DPRD
				1.27834e-006	FPRI
FPUI	CRA	AP	EXRT	TROP	
0.000109705	-7.30280e-005	-0.00294067	-0.000256056	-0.000368081	const
-4.16676e-006	-5.40066e-006	6.64352e-005	9.64196e-006	7.16712e-006	DPRI
-1.85222e-007	4.48272e-007	6.64171e-006	1.21974e-006	1.24786e-006	DPGE
-1.44249e-006	4.85881e-006	-2.18275e-005	8.14734e-006	-2.01480e-007	DPRD
-2.74270e-008	-6.14821e-008	5.17079e-007	1.07596e-006	-1.27469e-006	FPRI
1.62904e-006	-1.32287e-006	-1.36878e-006	1.07306e-006	-1.56169e-006	FPUI
	9.82453e-006	-2.85227e-006	1.72581e-006	-3.56942e-007	CRA
		0.000626761	-1.22172e-005	2.05169e-005	AP
			2.69859e-005	2.84962e-006	EXRT
				6.63624e-005	TROP

Source: Gretl output of Covariance matrix of regression coefficients.