Empirical analysis of Macro-Economic Variables towards Agricultural Productivity in South Africa

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DECLARATION

I the undersigned, T.C Setshedi student number 23115165, declare that this dissertation is my own original work and that all sources used are correctly acknowledged in references. I also declare that it was not presented to other universities for any other degree.

Signature : ………………………..

Date : 19 November 2018

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This dissertation is a journey from cradle to finish. In this journey of discovery many individuals have made massive contributions of which I would like to extent my acknowledgement to them. My sincere gratitude is entirely to the one above us all. I would like to give all the glory and honour to the Almighty God who has always guided me, shown me the light and his everlasting love and grace in everything I do. You are good always my Lord.

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DEDICATION

This study is dedicated to my one and only adorable son Onkabetse and my loving and supportive husband Romeo. Thank you for motivating me to further my studies. Your patience and support throughout this dissertation writing is highly appreciated.

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LIST OF ABBREVIATIONS USED

ADF:	Augmented Dickey-Fuller
AGRIBEE:	Agricultural Broad-Based Black Economic Empowerment
AGRISETA:	Agriculture Sector Education Training Authority
AIC:	Akaike Information Criteria
ARDL:	Autoregressive Distributed Lag
AX:	Agricultural Exports
BEE:	Black Economic Empowerment
BFAP:	Bureau for Food and Agricultural Policy
CPI:	Consumer Price Index
DAFF:	Department Of Agriculture, Forestry and Fisheries
ECM:	Error Correction Model
EU:	European Union
FPE:	Final Prediction Errors
FIFA:	Federation International de Football Association
GCF:	Gross Capital Formation
GCIS:	Government Communication Information Systems
GDP:	Gross Domestic Product
GE:	Government Expenditure
HQIC:	Hanna and Quinn Information Criteria
J-B:	Jarque-Bera test
KPMG:	Klynveld Peat Marwick Goerdeler
KZN:	Kwa-Zulu Natal
LR:	Likelihood Ratio

M2:	Money Supply 2
P.P:	Phillips-Perron
REER:	Real Effective Exchange Rate
RINT:	Real Interest Rate
SA:	South Africa
SADC:	Southern African Development Community
SARB:	South African Reserve Bank
SBIC:	Schwartz Bayesian Information Criteria
STATS SA:	Statistics South Africa
USA:	United State of America
VAR:	Vector Auto-Regression
VECM:	Vector Error Correction Model
WSP:	Workplace Skills Plan

ABSTRACT

Agriculture in South Africa since the past decades has contributed less than 3% towards growth of the economy and has not improved since then. Moreover, this is an indication that it is not where it should be as the middle-income country. However even though the sector does not play a growth-leading role in the economy of South Africa; it is playing a growth permissive role. Therefore, the study empirically investigates the impact of macroeconomic variables towards agricultural productivity in South Africa.

The Johansen cointegration and VECM approach have been applied to examine both the short-run and long-run relationship between macroeconomic variables and agricultural productivity over the period of 1975 to 2016. Three variations of equations were derived from the selected macroeconomic variables (gross domestic product, government expenditure, gross capital formation, consumer price index, real interest rate, real effective exchange rate, money supply and agricultural exports). The dependent variable which is agricultural productivity appeared in all those equations. Variations of results were established between the three equations with its dependent and explanatory variables.

In terms of cointegration results, the study finds that there is cointegration relationship existing among those three equations even after the study imposed restrictions on a certain equation. Therefore it is concluded that there is long run relationship among agricultural productivity and macroeconomic variables. The study employed a VECM for all three equations. The speed of adjustment and its t-statistics has been performed according to expectations. Diagnostic tests, granger causality and impulse responses were also analyzed. In conclusion, the results suggest that for South Africa to increase agricultural productivity, the state should give adequate financial support to the agricultural sector by ways of sponsoring skill development and funding improvement of agricultural infrastructure. Investment in the sector should be encouraged from private and public organizations to ensure sufficient support for farmers.

KEYWORDS: (Agricultural Productivity, Macroeconomic Variables, Vector Error Correction Model, South Africa)

CHAPTER 1

INTRODUCTION OF THE STUDY

1.1. Background of the study

The farming sector can impact optimistically to the nation's progression, social welfare, job creation, and food security. Most prominently, as South Africa is a developing country with a growing economy its agricultural sector needs to be improved. The agricultural productivity changes hinge on how agricultural output rapidly changes in relation to changes in level of inputs. However, the value of output per worker and yields per hectare are partial indicators of agricultural productivity that determine the change of agricultural productivity. Between 1960 and 1996 agricultural productivity grew approximately by 1.4%, however, in 1998 the productivity of the sector started to decline from 3.78% to 2.54% in 2011 Ramalai, Mahlangu and Tuit (2011).

In the 21st century, the shift of agriculture and agricultural productivity structure continued to indicate an ongoing decline on agricultural productivity by 0.19%. The slowdown of the sector's productivity was due to low productivity, particularly in output of field crops which are surpassed by development in the horticultural sector. Nevertheless the reality is that agricultural sector has contributed less than 4% to the South African economy since 2004, from its highest contribution of 21% in 1910 states the Department of Agriculture Forestry and Fisheries (2017). The growth of agricultural sector of South Africa continued to decline further in 2010 due to slow recovery of the economy and stagnant commodity of prices, Bureau for Food and Agricultural Policy (2011).

In recent years agricultural productivity total gross value in 2015 was estimated at R233 237 million, compared to R220 983 million in 2014 that was an increase of 5.5%. The increase was mainly due to growth in the value of animal products. In 2016/17 agricultural productivity had an increase of 12.5% when compared to the prior year of 2014/15.This was due to an increase of field crops and animal products and its share to GDP was approximately R80 247 million in 2016 DAFF (2017).

Moreover, 70% of agricultural products are used as intermediate products by other sectors of the economy. Those products are often partly processed, those include products such as vegetable oils, wheat flour, soybean meal among others. The agricultural sector is an imperative sector, and one of the engines that improve the growth of the economy. Nonetheless, to argue that the sector is more important than its share to the economy is understandable, as the sector utilised 79.8% of total land available in the year 2014 and used almost 60% of the water available for irrigation. According to World Bank (2017) the sector also generated R243 780 293 million in income and R225 522 070 million in expenditure. The sector created job opportunities directly and indirectly for more than 700 000 people in 2015, this was in line with the government New Growth Path plan to generate 5 million vacancies not later than 2020. This makes agricultural sector to be one of the biggest employers among other sectors of the economy.

Statistics SA (2017) indicates that the sector is more labour intensive when compared with other existing sectors, as it employs about 4.7% of labourers country wide. However, in relation to agricultural productivity and employment within, the sector offered a sustained livelihood previously and continues to do so. The sector employs majority of female workers compared to male. For example, among those employed on farms in the homelands, 220 of women employed resulted to 100 men employed.

Nevertheless, South Africa has reformed since post-apartheid era in 1994. The country has moderately amended. The agricultural sector has certainly not been the pillar of South African economy. Thus, this has been the reason behind the misfortunes of this sector. The poor governance and policy implementation inconsistency plays a leading role to lack of development when coming to the South African agricultural productivity Cristea, Marcu & Meghisan (2015).

It is crucial that the role of macroeconomic variables is investigated towards the productivity of agriculture. This is to put the actual productivity of this sector to perspective with the whole economy. Although the sector's share to GDP has fallen, it remains the leading agricultural exporter in some of the products. These include agro-processing products, maize and the cut flowers of protea. Those cut flowers of protea account to more than half of the proteas sold across global market. South Africa is the largest agricultural products importer to Europe, which imports almost one-half of agricultural exports of the country.

Furthermore, the country's import and export of agricultural products grew drastically in late 1990s to 2005. In the year 2005, South Africa imported approximately R16.7 billion of products and exported R25 billions of products. Therefore, imports of agricultural products grew by 7.9% whilst agricultural exports grew by 8.7% indicates Daya (2005). In 2010 the sector's total exports continued to grow amounting to approximately R52 billion which is 5% of South Africa's entire exports. However, the total imports grew to approximately R39 billion accounting to only 2% of total imports. The Agricultural exports revenue reached approximately 9% of total national exports, placing the country among the world's leading exporters and important trader in the African region according to Department of Agriculture Forestry & Fisheries (2011).

Moreover, since mid-1990s South Africa has not been a self-sufficient country in terms of the main food consumed. Therefore, the import substitution and self-sufficiency one can argue that importing most main food group would lead to rising of food prices. South Africa currently imports almost 50% of wheat and its white maize from its main sources which are Mexico and United State. These countries had roughly doubled their prices in the year 2015 fueling food price increase; this was the result of the severe drought that the country experienced in 2014/15.

The inflation rate of the country averaged to 9.20% from 1968 until 2017, reaching the unsurpassed high of 18.65% in 1986 and recorded a low of 1.38% in 2004. Furthermore, the inflation rose again, but policies were implemented to keep the rate below 6%. This target ensures that the inflation rate is controlled and does not go back to the way it was decades ago states World Bank (2017). In terms of trade, one would also argue that an increase in import of primary food would have severe pessimistic impact on agricultural trade balance, but the opposite occurs as the country is the net exporter of agricultural products by value. South Africa also established arrangements of trade preferential with countries that are in or out of the Southern African Development Community (SADC). Those reforms ended up lowering the standard of tariff levels and overview of tariff structure.

In terms of exchange rate of South Africa, Bronkhorst (2012) indicated that official currency of South Africa was introduced in 1961 being independent from the British colony. In 1983, key international banks and exchange rate system were abolished by government of the apartheid which refused to renew credit lines of the country. This action forced the temporary foreign exchange market closure in South Africa. Thus, it is critical to comprehend how exports of agriculture are linked to exchange rates in South Africa. Sibanda (2012) indicates that economic growth helps maintain an adequate foreign reserves level and to create and sustain a suitable international competitive agricultural exporting sector. Thus, it will alleviate and contribute to job creation and increase the share of agriculture to the economy.

According to the analysis executed by a variety of neo-classical and classical researchers it is certain that the sector has a crucial role in the country. The agricultural sector's position can thus, be shown in terms of maximizing productivity and minimizing production costs of food within the subdivision. Developing nations across the world can hinge on the sector to promote economic development. This may result to the readily available food and earnings from foreign exchange DAFF (2015). The similar studies were conducted by several researchers including (Umar, 2015, Kaabia and Gil, 2000, Akinlo, 2005 and Cristea, Marcu and Mehhisan 2015). However, there are limited studies focusing on the analysis of macroeconomic variables and its impact towards agricultural productivity in South Africa.

Furthermore, a study by Greyling (2012), investigated a relationship of agricultural performance on economic growth, the study had its limitations including lack of data. The study was qualitative one, hence, econometric techniques were not fully employed. Thus, this study's rationale is on macroeconomic variables that have an impact on agricultural sector and its productivity. In addition, this study employs econometric techniques of which in South African case there are limited studies that attempted to go this path.

1.2. Statement of the problem

As South Africa shifts to tertiary economy from secondary and primary economy, agricultural contribution to the economy keeps on declining. According to Kalaba (2015), the state of agricultural sector was put in an arduous position when the country decided to follow global rules of free trade after 1994. This led the sector to be expected to contest against the top economies in the world. Those changes in the structure and rules of agricultural sector led to overall downfall of agricultural productivity by 0.23% between 2000 and 2010. These changes meant that some of the farmers missed out on the opportunities to catch up with farmers of other countries. Those are farmers that had been supported and had a stable structure and rules of the agricultural sector. Ramalai *et al* (2011).

In most cases agricultural productivity tends to increase in first world countries when compared to developing countries. This is mainly because of their monetary saving in their own land, labour and capital along with improvements of inputs. This explains why productivity of South African agriculture has remained low for decades. It has limited investments and support for the sector even the decline in government expenditure to the sector plays a role to the state of agricultural productivity. Government spent R30 million to redistribute less than 7 million hectares of commercial farmland which are no longer in productive use and only 13% of its 1.2 million square kilometers is suitable for agricultural use says Ramalai *et al* (2011). Despite the land redistribution as observed by Nkamleu (2003), majority of farmers in South Africa are still in use of low yielding technologies of agriculture which leads to low productivity of the sector and reduces growth.

The South African agricultural sector has encountered challenges and the sector's input prices, it is not aiding in terms of productivity and growth. Input prices kept on rising more than the output prices leading to no growth in productivity. Consequently, the volatility in international oil price resulted to a negative impact on production costs. An unstable inflation rate along with exchange rate has not made agricultural productivity to be smooth either. High inflation rate due to environmental factors like drought often made it difficult for farmers to produce to their full capacity causing shortage on the main crops. Even more, the drought impact on food supply has been the key driver of sharply higher inflation, and this had implication on both consumers and farmers. Currently, South Africa is said to be the 30^{th} driest nation on earth.

Ramalai *et al* (2011), states that the growth of agricultural productivity is important even to other sectors of South African economy, as other sectors depend on inputs from this sector. Therefore if agricultural productivity decreases, this lead to productivity of other sectors to decrease due to limited inputs. However, Liebenberg (2013) undertook study of agricultural productivity and public-sector investment and the results indicated that there is insufficient investment to improve the sector. Letsoalo and Kirsten (2003) modeled agricultural productivity and its impact on macroeconomic and trade policies. Greyling (2012) in the study undertook, results indicated that agricultural exports does not play a growth leading role and agricultural productivity had failed to meet the demand of main food products this resulting to increase in food and general inflation.

Consequently, there have been contradictions when it comes to studies of agricultural productivity and its impact on macroeconomic variables. Limited literature is available for the study in South Africa. It is not clear even now on how certain macroeconomic variables are impacting agricultural productivity. Therefore, this prompts the need for further research to comprehend thoroughly the impacts of agricultural productivity on macroeconomics in South Africa.

1.3. Objectives of the study

The key objective of the study is to investigate the impact of macroeconomic variables towards agricultural productivity. This key objective is divided into sub-objectives that follow:

- To provide review of the trends of macroeconomic variables and agricultural productivity in South Africa.
- To develop econometric model and determine the long-run relationship between macroeconomic variables and agricultural productivity.
- Identify macroeconomics variables which impact agricultural productivity in South Africa.

- To provide useable policy suggestions that can be implemented to improve the agricultural productivity in South Africa.

1.4. Research questions

- Does long run relationship between macroeconomic variables and agricultural productivity exist in South Africa?
- Does causality exist between macroeconomic variables and agricultural productivity?
- Do macroeconomic variables have any significant impact on agricultural productivity?
- To what extend can this selected macroeconomic variables influence agricultural productivity in South Africa?

1.5. Research hypotheses

The following null hypotheses are considered for the study.

- There is long relationship among macroeconomic variables and agricultural productivity in South Africa.
- There is causality existing between macroeconomic variables and agricultural productivity.
- There is significant impact of macroeconomic variables in agricultural productivity.
- There is an influence of macroeconomic variables on agricultural productivity

1.6.Research method

To carry out this South African study, a time series is used. Agricultural productivity is expressed as (agriculture share to GDP) acting as a dependent variable along with gross domestic product, government expenditure, gross capital formation, consumer price index, money supply (M2), real effective exchange rate, real interest rate and agricultural exports as independent variables. This study empirically investigates the impact of macroeconomic variables towards agricultural productivity in South Africa. A time series data is used for the period from 1975 to 2016. The variables used were subjected to the Augmented Dickey-Fuller (ADF) and Phillips-

Perron unit root tests. Vector Error Correction Modeling (VECM) by Johansen (1991) & (1995) are employed. In addition, the impulse response and granger causality are included along with the diagnostic tests.

1.7. Justification of the study

Although South African agriculture has contributed less than 3% to GDP since the 21st century, it is still regarded as one of the important sector within the country's economy. This is because food security, reduction of poverty and job creation are government top priorities. Therefore this study explores how macroeconomic variables impact agricultural productivity in South Africa during the era of apartheid and post apartheid era. As previous empirical evidence does not give thorough analysis on macroeconomic variables and agricultural productivity relationship in South Africa, and limited studies have been conducted relating to this kind of a study.

Therefore this study will fill the gap of the above empirical literature by adding other key macroeconomic variables that were not included in the studies. The study will attempt to analyze the results using three variations of equations. It is on this basis that this study adds value to the few of empirical literature available. The study will further focus and discuss on what extend does macroeconomic variables have an impact on agricultural productivity in South Africa. Rather than focusing on environmental factors of which most of among the limited studies in South Africa focused on. The study will also assist in improving agricultural policy implementation and accurate analysis so that the sector can have more entrepreneurs to ensure food security, nutrition wellbeing and job creation in the country.

1.8.Organization of the study

The study has six chapters, whereby Chapter 1 of the study provides among others the introduction and background. Subsequently, Chapter 2 gives the structure of agricultural sector of South Africa. In addition, the chapter reviews agricultural trends within South African provinces also provides the policies that constitute agricultural sector. Chapter 3 evaluates both theoretical and empirical literature. Methodologies to be employed are discussed thorough in Chapter 4. Second last is Chapter 5 presenting the results and empirical analysis of the findings.

Lastly, Chapter 6 summarizes then conclude and provide policy recommendations along with limitations of the study and suggestions for future research.

CHAPTER 2

THE STRUCTURE OF AGRICULTURAL SECTOR IN SOUTH AFRICA

2.1. Introduction

The intention of chapter two is to examine the South African agricultural structure along with its growth trends and geographical structures among others. Agriculture in South Africa plays a limited role within the country's economy. This is seen as the sector provides intermediate goods to other industries and food security to citizens of the country. The sector focuses on the production of livestock and plantation of crops, it also includes ways to expand and make use of the land that is appropriate for the raising of crops and plants, digging channels for water conservation and other forms of irrigation. Foundation of agriculture is mostly seen through pastoral herding of livestock on range land and crops cultivation on arable land.

Improvement of the agricultural sector has resulted to the advancement of civilization of human with the husbandry of plants and domesticated animals. The sector ended up creating a dependable source of food security for heavily stratified population. As the country has nine provinces, every province has an area of specialization in the agricultural sector. Therefore, this chapter presents the structure of agricultural sector in section 2.2. Then section 2.3 presents the growth trends of the sector while section 2.4 focuses on the geographical locations of agriculture. Then section 2.5 discusses few of the macroeconomic variables trends towards agricultural productivity and lastly section 2.6 presents the policies constituting the sector.

2.2. Agricultural structure of South Africa

The agricultural sector is the basis of poverty reduction and unemployment reduction in most rural areas, and to an overall economic growth, DAFF (2011). South African households in the year 2009 contributed 20.7% directly to agricultural production. The leading household groups engaged in agriculture activities are in the provinces of Free State, Limpopo, Eastern Cape, and KwaZulu-Natal. According to AgriSETA (2017), the main commercial farming appears to be in North West, Western Cape and Free State provinces. However there's a reduction in commercial farming enterprises number ranging from 45,818 registered in 2002 to 39,982 in 2007. This raised questions about the specific requirements for future sustainability of the commercial agriculture sector and South Africa's food sustainability potential Abrahams and Akinsanmi (2013).

More significantly, it raises questions for considering support interventions to skills development for building a 21st century agricultural sector, mainly for advanced small and emerging black farmers AgriSETA (2010). However, there are several issues impacting agricultural productivity negatively in South Africa. Those issues include barriers set by local conditions such as water availability, farm safety and security, skills demand and supply, technological adaptation, and adequate agricultural research that would help in addressing issues such as the obtaining best use of land and climate. This sector is highly diversified different with lots of activities happening within.

2.2.1 Activities within the agricultural sector

Activities within the agriculture sector compromises of certain branches stated as follows: field crop husbandry, dairy farming, animal production, agro-processing, game farming, horticulture and fish farming. Within those branches there are several sub-sectors whereby they include both primary and secondary activities. Below is a table of detailed sub-sectors along with its description.

Table 2.1 Activities within the agriculture sector

Sub-sector	Description
Tea/Coffee	Processing and marketing of tea and coffee along with dates, cocoa, nuts, coconuts, olives etc.
Fruit	Fruit juice in containers and fruit juice concentrate drummed.
Fruit	Fruit imports and exporters.
Grain	Manufacturing of starches and grain mill products. Storage and handling of grain. Retail trade and wholesale in agricultural machinery.
Milling	Manufacturing of grain flour and grain mill products, including vegetable and rice milling. Manufacturing of animal feeds. Manufacturing of starches and starch products.
Seed	Seed production and marketing.
Primary	Growing of nursery products, horticultural specialties and vegetables. Plantation of sugar including sugar beet and sugar cane etc. Growing of spice crops, nuts, fruit and beverages. Farming of sheep, cattle, horses and goats; Dairy farming. Farming of animals and growing of crops. Growing of Cereals. Services of animal husbandry and agricultural.
Red meat	Production and animal products. Slaughtering, dressing and packing of livestock. Production, sale & marketing of agricultural by products. Agricultural and livestock research.
Poultry	Poultry and production of egg including the slaughtering, dressing also poultry packing.
Sugar	Manufacturing of sugar including castor sugar and golden syrup.
Tobacco	Processing tobacco and dispatching it.

Source: AgriSETA, 2015

Above tables 2.1 indicate a diversification of the sector, it includes all products produced within the sector and how each product is distributed. Some of these products for example: sugar whereby most of it is produced through sugar canes, therefore used for secondary activities. In addition it includes manufacturing of golden syrup and castor sugar. The above table indicates also the main contributors to the growth of agricultural sector by means of activities within the sector. Main contributors such as poultry meat, production of crops (maize, sorghum, wheat, barley), sugar cane, fruits, vegetables and dry beans. Most of the South African households spend more than 70% of their budget on those main contributors, however that happens after those products have been processed e.g. meat (25%), maize, bread and cereal (26%), milk, cheese and eggs(9%) and vegetables(10%) indicates Greyling (2015).

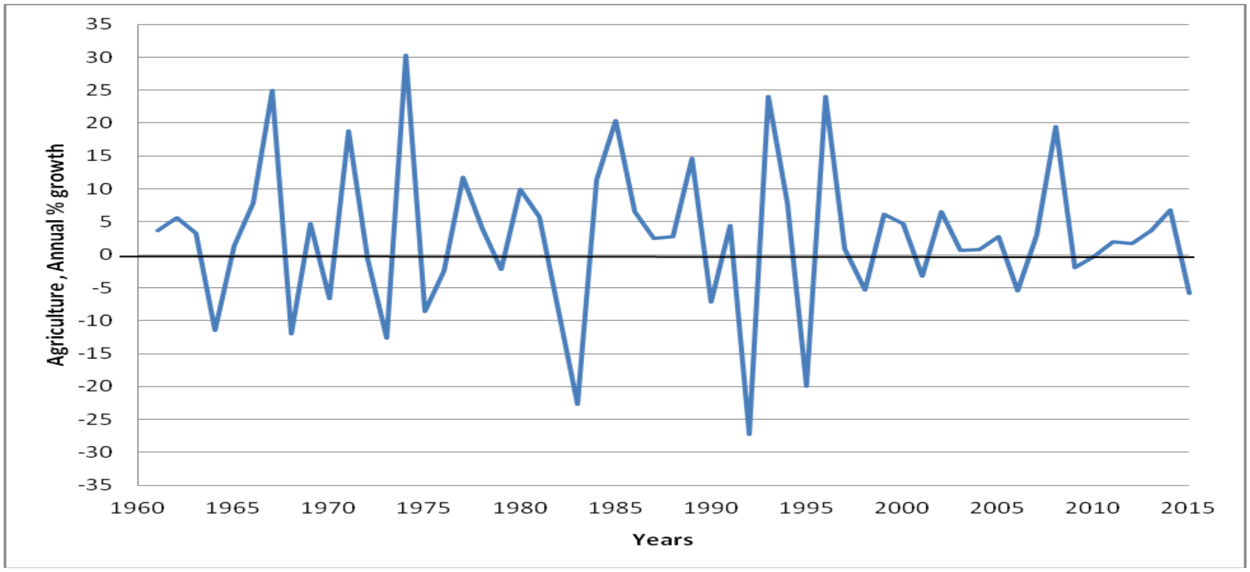
Nonetheless, the history of South Africa's agriculture from the 1960s advanced at an improved rate of growth and important developments took place. According to the DAFF (2017), the government regulated both commercial agriculture marketing phases and the production in the early 1990s. Marketing boards were appointed by government to buy main consumer crops such as various cereals, milk and corn at fixed prices.

2.3.Growth trends of Agricultural sector in South Africa

Since 1994 agricultural sector shown growth of approximately 2.2% per annum, while the economy grew by 3.3% annually in the same period. This resulted in a decline in agriculture's share of GDP from 2.8% in 1994 to 2.1% in 2016 DAFF (2017). Those changes were due to policy changes which resulted to elimination of existing control and the decline of government spending in the sector and lack of support on producers of crops.

The agricultural sector has constantly been declining for the past decade and continues to decline. Nonetheless it remains the crucial sector in the economy with its role of providing food security to the citizenries and being able to contribute internationally. Among other ups and downs of the sector, in 2007 the sector experienced a loss of R3 562 million. However, between 2008 and 2009 agricultural production grew by 13.7% amounting to R126.7 billion in value. When coming to its capital, the SARB indicated that in 1990s control stock decreased from R120 billion to R110 billion in 2009 AgriSETA (2010). Detailed explanation of the agricultural sector trends is explained in the following graph.

Figure 2.1 Agricultural sector annual % growth (1960-2015)



Source: World Bank, 2017

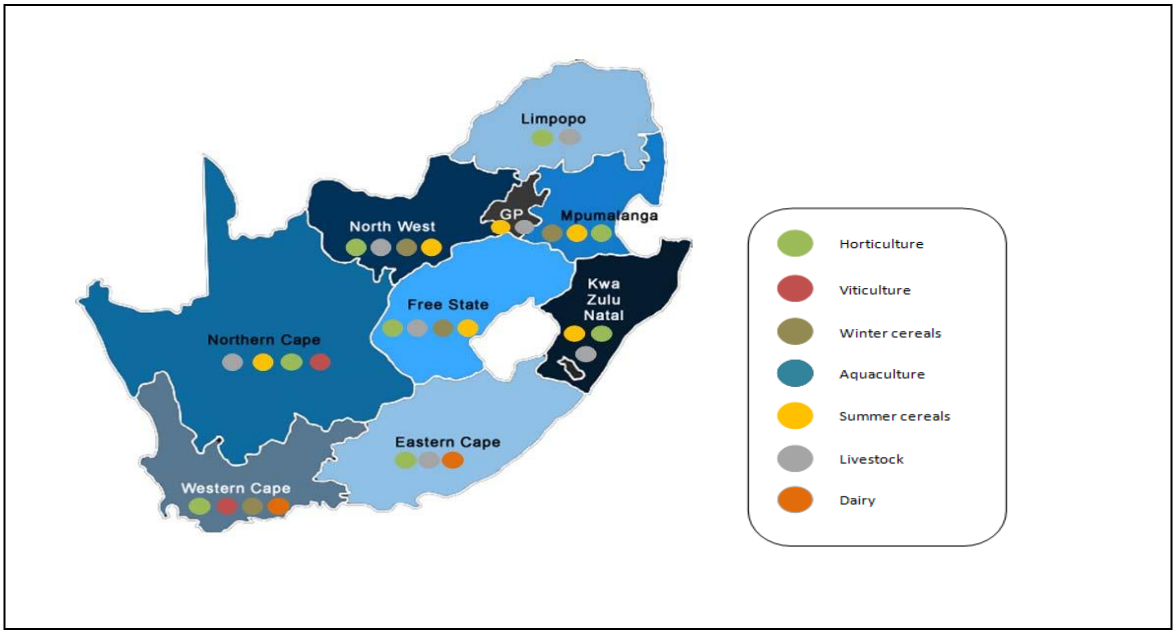
Figure 2.1 indicate that in 1961 the sector grew by 3.7% but decreased to -11.45% in 1964 the decrease was mainly to the decline of summer cereals. Thus, as the years goes by it increased its growth to the value of 25% in 1967. In 1981 the flood occurred and this resulted to huge losses in crops and stocks. Subsequently in 1983 agricultural sector recorded a negative growth of -22% which was due to the severe drought, political and economic instability. As climatic conditions have major impact on the productivity of agriculture, the severe drought that occurred in 1992/1993 had serious impact on the growth of agricultural sector in South Africa reaching all time negative growth of 27%. According to the Department of Water Affairs (2004), another minor droughts occurred in 1997/1998 and 2001/2002 these droughts makes the country to be vulnerable to effects of drought due to the agricultural production dry-land.

Nevertheless the country recovered with a negative in the year of 2009 where it was hit by economic recession of which it resulted to -1.8%. In 2011 it recovered with annual growth of 14% the growth afterwards declined to 6.8% in 2014. Thereafter, in 2015 the sector was affected again by the drought which it reduced the production of wheat and maize resulting to the sector recording -5.8% annual growth.

2.4. Geographical breakdown of agriculture

In terms of geographical locations of the sector, all provinces have different focuses when it comes to their strategies of development for the agricultural sector. However, even though the main principle is to improve lives of the people through provision of food security and agricultural employment. Those principles are achieved through agricultural investment processes and technologies that enhance efficiency.

Figure 2.2 Geographical location of agriculture within South African provinces



Source: DAFF, 2017

The above figure 2.2 shows that in Limpopo, the focus is on horticulture and livestock while in North West and Free State is the combination of horticulture, livestock, winter cereals and summer cereals. These two provinces seem to focus on similar production within the agriculture sector. Whilst Northern Cape focal points are viticulture, summer cereal, horticulture and summer cereals. Gauteng and Kwa-Zulu Natal are presented by summer cereals and livestock although Kwa-Zulu Natal includes also horticulture. Western Cape is indicated to focus of horticulture, viticulture, winter cereal and summer cereal. The Eastern Cape focus is on horticulture, livestock and dairy, lastly Mpumalanga is involved in winter cereal, summer cereal and horticulture.

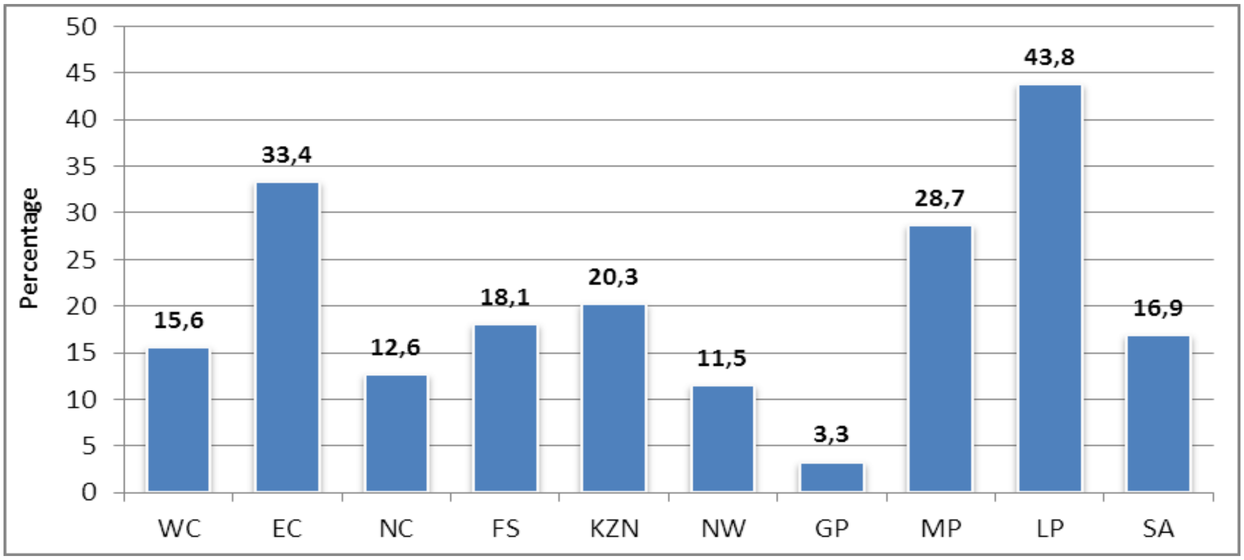
Table 2.2 Detailed table showing off agricultural dominant production locations

Products of Agriculture	Dominant production location	Produced annual average volume
Maize	Free State, North West and Mpumalanga	7.3 million-ton, number decreased due to the impact of 2015 drought
Wheat	Western Cape and Free State	1.4 million ton
Sunflower seeds	North West, Mpumalanga , Free State and Limpopo	742 750 ton
Soya beans	Free State, Mpumalanga, KZN, Gauteng, North West and Limpopo	750 250 ton
Sorghum	Limpopo, Free State, Mpumalanga and North West	88 500 ton
Sugar	Eastern Cape, KZN and Mpumalanga	245 000 ton
Wine	Western Cape	1156 million litres produce d in 2015
Subtropical fruit and citrus	Limpopo, Eastern Cape, KZN, Western Cape and Northern Cape	2 470659ton, gross value of R12.6 billion
Potatoes	Limpopo, Free State and Western Cape	-
Onions	Mpumalanga, Western Cape, Free State and Limpopo	417 579 ton
Tomatoes	Limpopo, Mpumalanga, KZN, Eastern Cape and Western Cape	230 000 ton
Poultry and pigs	All provinces	
Dairy	North West, KZN, Eastern Cape, Mpumalanga and Western Cape	-
Tobacco	Mpumalanga, Limpopo, North West, Eastern Cape and Western Cape	15 million kg
Tea	Western Cape and Eastern Cape	200 ton
Livestock	All provinces	Gross value of R50 billion

Source: GCIS, SA Yearbook 2015/16

The above table 2.2 presented the detailed table which indicated the agricultural dominant production locations. It is clear that the sector is diverse when coming to its products. This tables act as a guide on which province should focus on, when coming to the production of agricultural products. Among others, Canola and wine are shown to be produced in the Western Cape while sorghum is produced in Free State, Mpumalanga, Limpopo and North West.

Figure 2.3 Households involved in agriculture by province in percentage, (2015)



Source: Stats SA-General household survey, 2015

The above figure 2.3 indicates that the major province that participated in agriculture is Limpopo province with its share of 43.8%. This province was followed by Eastern Cape with 33.4%, and 28.7 of Mpumalanga along with Kwa-Zulu Natal by 20.3%. North West, Free State, Western Cape and Northern Cape are below 20%. Lastly, Gauteng is the lowest province that participates in agriculture with its share of 3.3%.

2.5. Trends of some macroeconomic variables selected

This study focuses on selected macroeconomic variables impacting agricultural productivity; hence, it is crucial to explore their trends and how they impact agricultural productivity. In addition, this section will get into more detail with certain variables, whereby it will explain history and growth trends of those variables. These macroeconomic variables were carefully selected through the guidance of previous empirical literature : see Lumpur (2015), Browson (2012), Zainab and Umar (2015), Enu and Atta-Obeng (2013) and Abba, Barro & Mosca (2015).

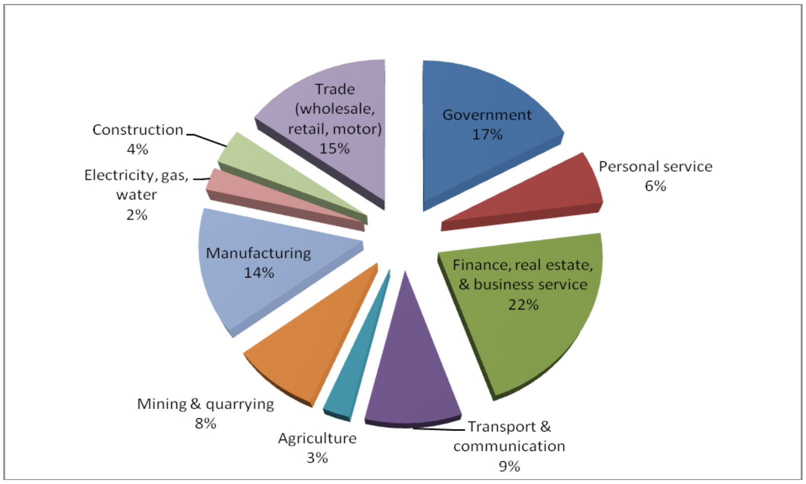
2.5.1 Growth Domestic Product

South African GDP decreased in between 1970s and beginning of 1980s. This was due to the rising of oil imports prices along with international competition in some export commodities and the decline of gold revenue. In 1976 the first recession occurred, whereby it rose oil prices and other commodities according to Industrial Development Corporation (2013). Conversely, export growth on increased gold prices assisted the economy to recover from the recession. This was followed by the drought in 1980s ending up affecting agricultural productivity. The slow growth in 1980s affected the living standards, this resulted to population growth outpace economic expansion.

The economy then recovered in 1994, whereby GDP amounted to approximately R433.8 billion, this represented the 2.6% real growth over the previous year of 1993. The country was positioned among upper middle income developing countries of the World Bank's due to the increase in per capita GDP. Conversely, the country's economic growth has had its ups and downs, looking at the global monetary crisis that occurred in 2007 resulted in 2009 global recession. On the contrary, the country recorded its highest growth rate in 1960s, between 2004 and 2007 with the share of 5.2% annually, IDC (2013).

GDP growth in the country declined to 1.6% in 2009 and rose to 4.6% in the first quarter of 2010 this was a boost from the FIFA World Cup 2010 which was hosted in South Africa IDC (2013). Therefore, below are all industries contributing to GDP of the country along with their share:

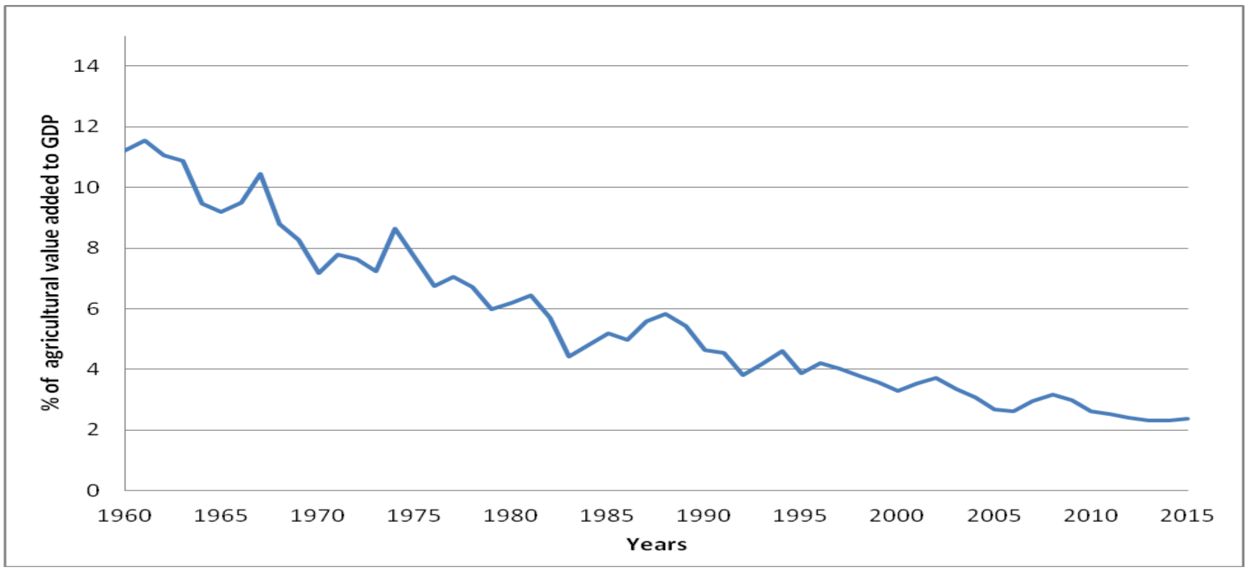
Figure 2.4 Sectors contributions to South African GDP, (2015)



Source: Stats SA, GDP data, 2015

In the above Figure 2.4, in 2015 electricity, gas and water along with agriculture and construction sector showed a smaller contribution to the GDP. In addition, manufacturing also declined compared to the 18%in 2001. 19% of total employment is from the mining, manufacturing and agriculture sector as they are labour intensive sectors and employs most unskilled workers. This has decreased from roughly about 30% in the year 2000. Nonetheless, the services sector now accounts for 72% of total employment.

Figure 2.5 Share of Agriculture to GDP in %, (1960-2015)



Source: The World Bank, 2017

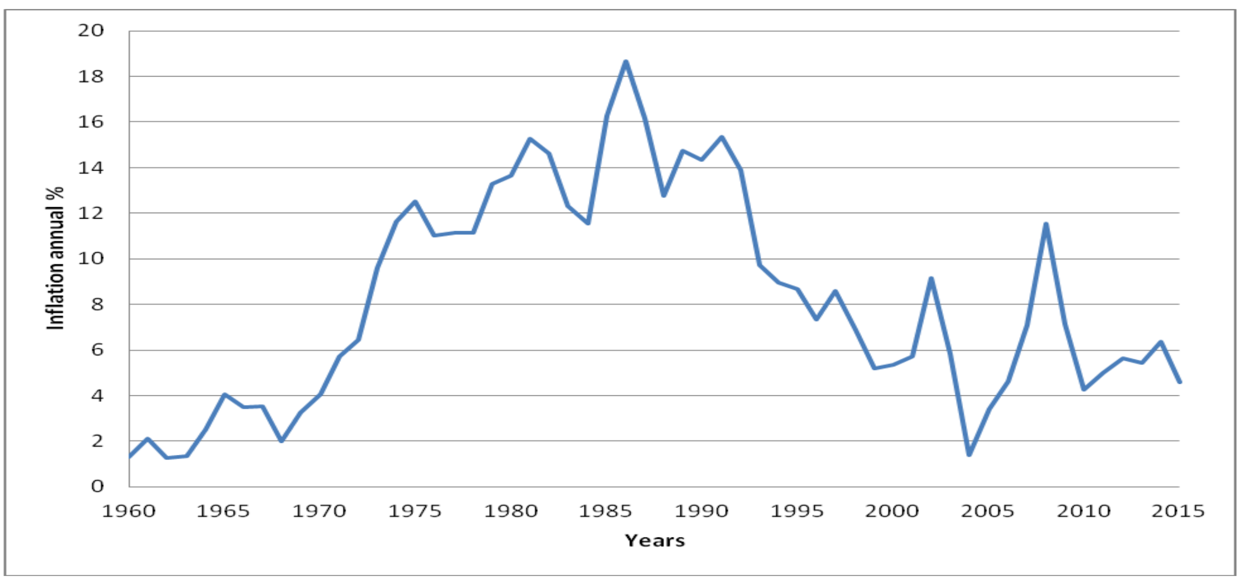
Figure 2.5 indicate the share of agriculture to South African GDP, and by taking a closer look in to its trends it clearly indicates that year by year agricultural share decreases. In 1966 its share amounted to 9.4% compared to 11.05 in 1961. The share decreased excessively in 1982 with a share of 5.6% due to drought that took place. It therefore improved slightly in late 80s. Afterwards, the agricultural share continues to deteriorate significantly from 1995 till present whereby it only contributed 2.3% in 2015.

2.5.2 Inflation

The South African inflation rate rose remarkably in the 1970s and 1980s, however this took place in most of the parts of the world due to oil price shocks. As time went in the early 1980s, the main traders of South Africa experienced smaller levels on inflation. In South Africa inflation remained high due to high growth broad money supply than its trading partners. Agricultural sector in the early 1990s experienced debt and high inflation that affected other sectors of the economy. Farmers had also witnessed weakening in terms of trade in farm products, Vink and Van Rooyen (2009).

In addition, the country faced reduction of harvests which resulted to the severe drought in beginning of 1990s. The change in food prices had an influence on consumer price index. This is shown by the fact that in 1990 the food prices accounted for 18.6% weighing structure of CPI. Consequently, the food prices in 1985 were even higher at 22.7%. This variety of fluctuations contributed to the disturbing movement of CPI being a higher level. Continuing droughts tend to carry on putting an upward pressure on agricultural products Pretorius and Smal (1992). Therefore, below is the detailed graph explaining the trends of inflation rate in South Africa.

Figure 2.6 Annual Inflation rate of South Africa, (1960-2015)



Source: The World Bank, 2017

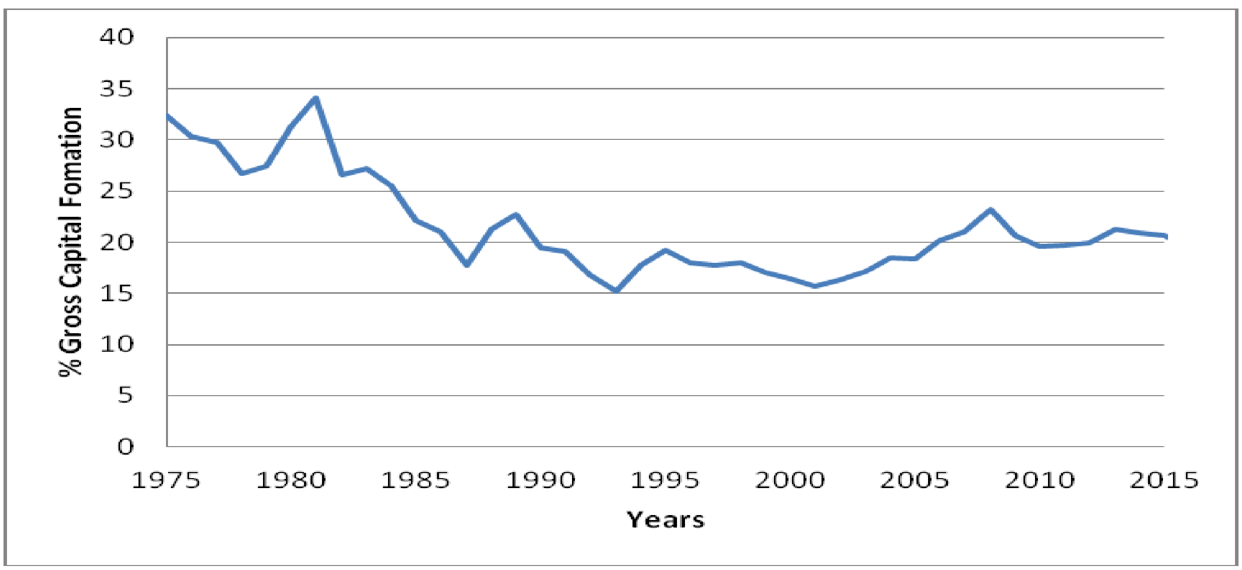
The change of food prices has a considerably influence on consumer price index. Consider looking at figure 2.6, previous inflation rate compared to current rate, one can say that inflation is at ease. In 1986 inflation rate recorded 18.2% which resulted to be the highest since 1960.

Between the periods of 1974 to 1992, the inflation rate was more than 11%. Even though afterwards, it continued to decline, recording the lowest in 2004 with a share of 1.3%. In 2008 it increased to 11.5%. Thus, in 2000 South Africa has adopted an inflation targeting monetary policy approach to keep inflation rate between 3 and 6 per cent. However sometimes it is difficult to do so, as in 2014 inflation rate was 6.09% and continued to increase to 6.34% in 2016 due to the drought that took place in 2015.

2.5.3 Gross Capital Formation

The relation between growth rate of real output and share of gross capital formation (investment) in agricultural productivity has been a critical area under discussion of analysis in all nations developing and developed. Investment in physical capital is a key factor in explaining real output in this case in explaining level of agricultural productivity. Levine and Renelt (1992) explain that in both demand and supply side in agricultural production, gross capital formation contributes to sustainable growth in agricultural production because part of these expenditures are committed to firm's fixed capital renewal.

Figure 2.7 Percentage of gross capital formation of South Africa, (1975 to 2015)



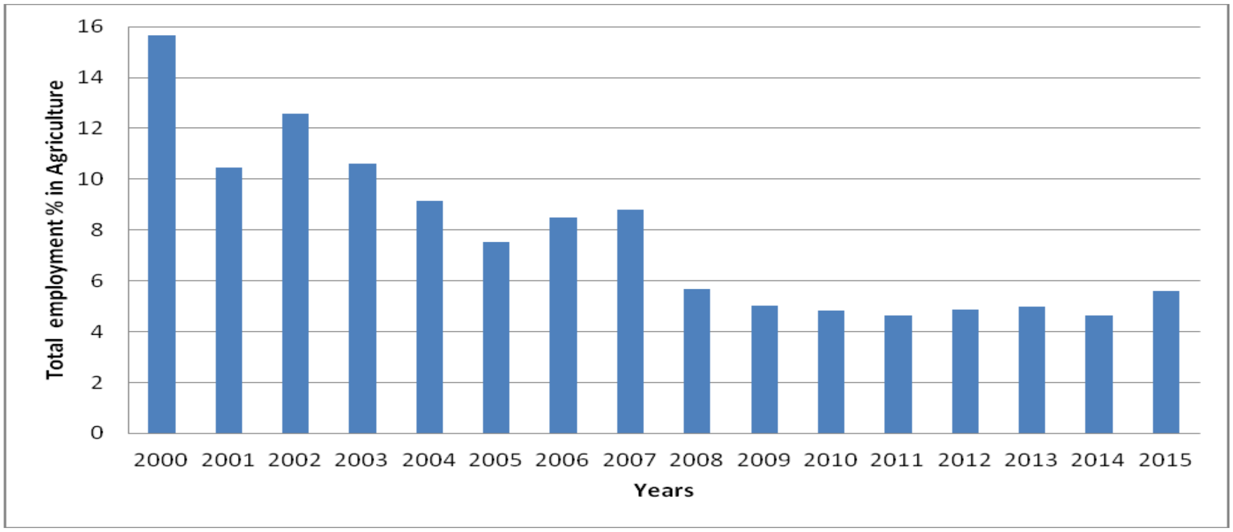
Source: The World Bank, 2017

Figure 2.7 shows trends of gross capital formation in South Africa, and it can be said that beginning of the 1980s gross capital formation was at its highest till 1983. Whereby it further declined to less than 20% till 1990. After the 1990s it continued to trend up and down between 15% and 25% up until 2015 where it was 21%.

In terms of investment, physical capital is a principal factor in explaining real output of agricultural productivity, it is of necessity to glance into labour force within the agricultural productivity. According to AgriSETA (2016), in rural areas the agricultural sector is the main employer across all those rural areas in the country. The sector employs approximately 898 000 people, whereby this represent 5.7% of the total labour force in the country. This makes the sector to be labour intensive as it employs more people compared to manufacturing and mining. It also indicates that the sector has shed more labour and decreased the value of production recently as its share to the economy decreases. The horticulture, sugar and wine industries of Limpopo, Western Cape and KwaZulu-Natal employ greater part of the workers within the sector.

The payment or wages for labour or services rendered within the agricultural sector can be paid on a monthly, weekly, daily or hourly basis or by the amount of work done by individuals. Agricultural sector remunerations have been the lowest the country before the introduction of minimum wages. Below is figure 2.8 that indicates the trends of employment in agriculture sector.

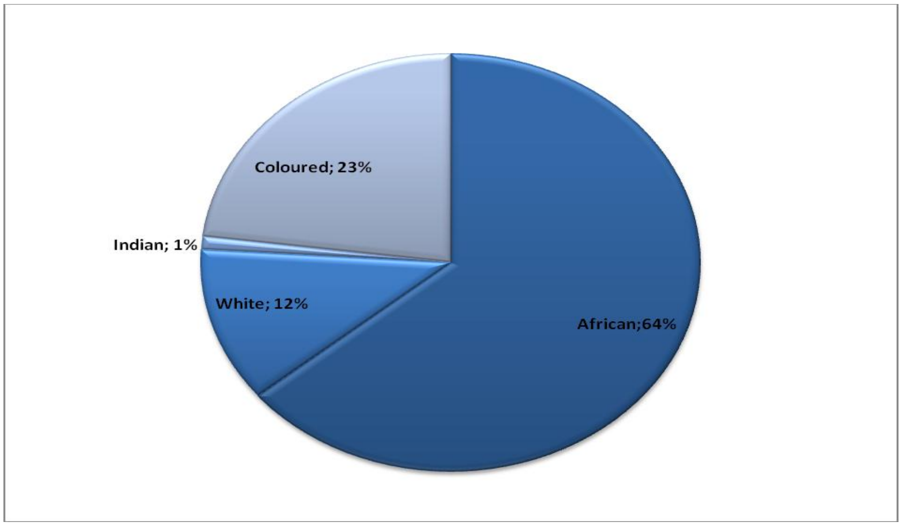
Figure 2.8 Total employment in Agricultural Sector in South Africa, (2000-2015)



Source: World Bank, 2017

According to the World Bank 2017, total employment in agriculture compromising of all genders and races amounted to 15.64% in the year 2000. The employment therefore decreased significantly from the year 2000 to 2001 from 1.4 million jobs to 861 jobs in just one year. Thus, the employment in the sector increased to its peak again to offering 1.2 million jobs in 2002 (12.57%) however afterwards it continued to decrease reaching 7.52% in 2005. In 2010 it deteriorated reaching a decrease of 650 000 jobs (4.83%) this have been to an economic recession faced by the country in 2009. The employment in the sector continued to decline to reach 4.64% in 2014. Subsequently, in 2015 it slightly increased by 0.95% employing 5.59% total workers in the sector.

Figure 2.9 Employees in agricultural sector by race, (2015)



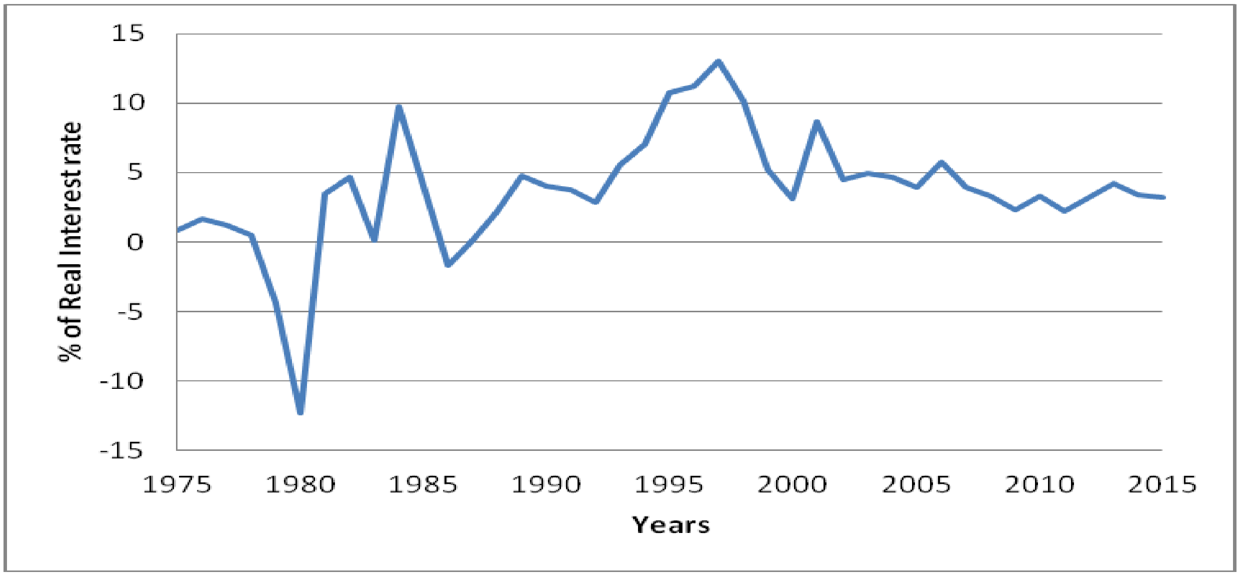
Source: AgriSETA WSP Submission, 2016

According to figure 2.9, Black Africans are majority group employed within the agricultural sector by 64%. They are therefore followed by Coloured race compromising of 23%, thereafter Whites by 12%. Lastly, the Indians have only 1% of employees in the agricultural sector.

2.5.4 Real Interest Rate

There is a growing discussion in emerging market on an appropriate monetary policy choice that could lead to sustainable agricultural productivity Davidson (2007). Targeting inflation has become part of the policy alternatives and has since been implemented in South Africa in 2000 and in some emerging markets in Latin America and Asia. As suggested by economic theory, lower and positive levels of inflation lead to an increase in agricultural productivity. Figure 2.10 below gives trends of real interest rates in South Africa as of 1975 to 2015.

Figure 2.10: Real interest rate of South Africa, (1975-2015)



Source: SARB, 2018

As depicted in Figure 2.10, real interest rates were very low in 1980 however it managed to rise in 1982 and fluctuated till 1993. Interest rate was on a clear upward trend after 1994 until 1998 and mostly above 7%. Shelile (2006) explains that the increase was a result of the monetary policy instrument adopted by the SARB during that period. In that period, for SARB to achieve its objective of protecting the rand through low inflation, the bank used money supply rather than interest rates as a way of fighting inflation. Frederick and Fouri (2009) argue that low growth rate in money supply has led to increases in interest rates for the same period between 1996 and 1998. The interest rates started to trend downwards from 1999 to 2000 and continued to decrease in 2001.

The reduction in interest rates was related to the inflation targeting policy adopted by the SARB in 2000. According Shelile (2006), the temporary increase in 2002 was due to supply shocks in the country resulting from the global financial crises pressure. In late 2006 interest rates started to rise again. The increase was a result of financial turmoil due to the crisis that originated from the United States of America in 2007 and 2008 Havrylchyk (2010). The SARB managed to reduce interest rates in 2009 to achieve inflation targeting. In the year 2010 the interest rates started to pick up again till 2015 however it managed to be kept at less than 5% increase. From

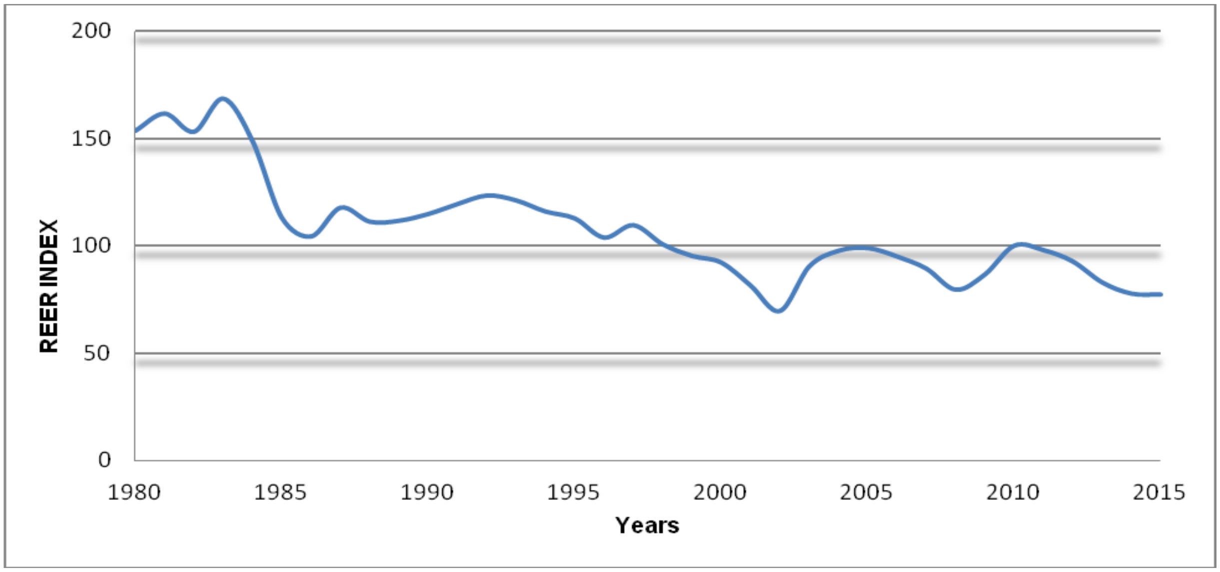
Figure 2.10 it is evident that changes in real interest rates triggered some changes in agricultural production.

2.5.5 Real Effective Exchange rates

The South African currency was officially established in the year 1961. It was then developed into a liquid emerging market currency, and the currency was then traded against the US dollar. Before the establishment of the currency in 1961, the country was under a British colony, using the British pence, shilling and pounds. Since 1994 democratic elections, some developments have returned to the country's international relations. However the real exchange rate of the country remained as a downward trend against the US dollar for a long term Bronkhorst (2012). New government of the country in 1994 affiliated political instability which resulted to weakening of the rand to an average of R3.49 against the dollar Sihlobo (2007).

Attacks that occurred in USA World Trade Center in 2001 caused the rand to appreciate to R13.83 to the US dollar this was its worst level ever, nonetheless it recovered in the following year Bronkhorst (2012). However local events, such as socio-political instability, increasing debt and energy issues have kept the rand in a weakened position. The movements of exchange rate in South Africa are indicated in the following figure 2. 11:

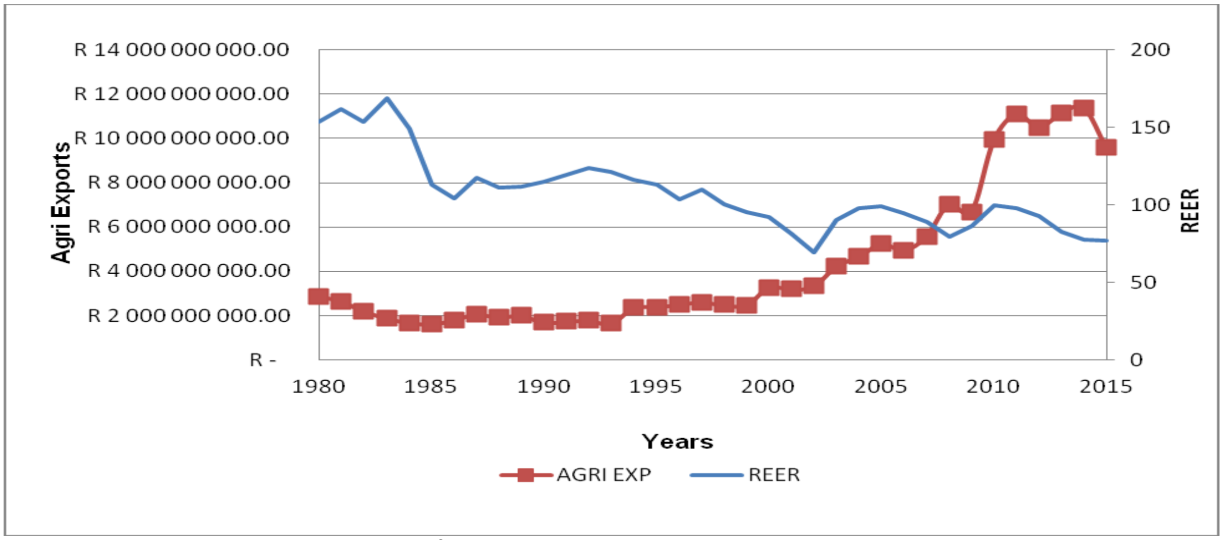
Figure 2.11 Real Effective Exchange Rate trends of South Africa, (1980-2015)



Source: SARB, 2018

Figure 2.11 shows that the real effective exchange rate continued to depreciate overtime. This tells that the SARB was able to stabilize the REER and this benefited the agricultural exports and made the industry more competitive. The REER index appreciated from 104 in 1986 to 112 in 1995. In the year 2000 it continued to depreciate recording 92, therefore slightly appreciated in 2011 to 97. Thereafter, real effective exchange rate depreciated further to 77.1 during the year 2015.

Figure 2.12 Agricultural exports and REER of South Africa, 1980-2015



Source: Own compilation with data obtained from DAFF and SARB

In the above Figure 2.12 plots South Africa's real effective exchange rate against exports. The fall in agricultural exports caused a depreciation of 113 on the REER in the year 1985. Nonetheless, South African high inflation rate along with portfolio capital appreciated the REER during 1980s. Despite disadvantageous real exchange rate between 1990 and 1992, the country's agricultural exports grew. Depreciation in the REER positively impacted the South African competitiveness of agricultural exports; this resulted in an increase in the country's agricultural products exports.

In export markets the value of the rand to the US dollar directly influences the competitiveness of agricultural products and commodities of South African. A simple illustration of this would be to look at the 2015 marketing season of grains. The rand to the US dollar exchange rate was an accurate indicator of the movement of South African grain prices - particularly maize and wheat. The country is traditionally a net importer of wheat and exporter of maize. However, during marketing year of 2015, South Africa became a net importer of both grains due to drought.

2.5.6 Agricultural exports

South African agricultural exports contributed 5% to 10% of earnings from total exports, although it was an insufficient share. However, wheat, sugar and maize which are mostly exports of domestic surplus most of the times incur a loss given the market price of the world. Oilseeds and red meat are the major deficits which in regular basis are requisite to be imported along with inputs of agriculture DAFF (2017).

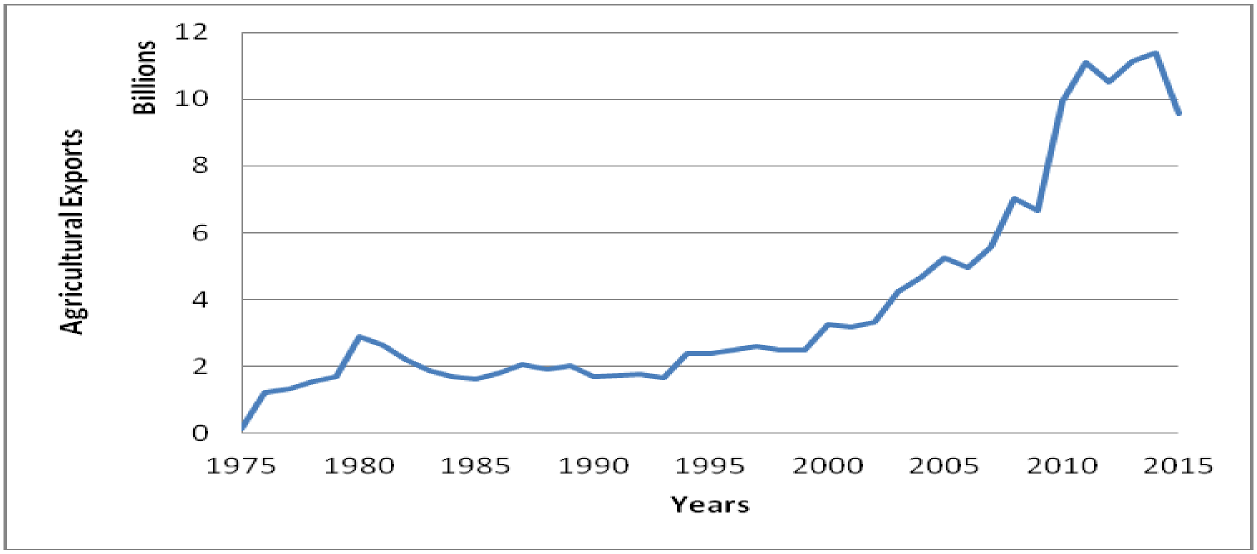
Table 2.3 Top countries exported agricultural products from South Africa, (2015)

Counties	Rank
Netherlands	1
United Kingdom	2
Mozambique	3
Zimbabwe	4
China	5

Source: DAFF, 2017

Table 2.3 shows the five largest trading partners that exported agricultural products from South Africa during 2015 was Netherlands with exports products valued at R9 256 million. United Kingdom imported agricultural products valued at R8 533 million, then Mozambique R6 016 million, Zimbabwe R5 125 million and then China with R4 649 million.

Figure 2.13 Agricultural exports growth trends for South Africa, (1980-2015)



Source: The World Bank, 2017

Above figure 2.13 shows that from 1975 to 1993 agricultural exports increased steadily. On the other hand, between 1994 to 2004 agricultural exports tends to pick up more from estimation of 1.4 billion to 4.6 billion. Export volumes increased from 5 Billion tons in 1997 to 7 billion tons in 2005. However, after 2002 exports declined because of the rand appreciated against the dollar. Even though a decline in exports took place in 2003 and 2004, which was also overlapping with drought years. Exports continued a growth path in value terms until 2006.

In 2008 grains quantity exported indicated an increase of over 1.4 million tons after its decline in the previous years in 2006 and 2007. A sharp decline in quantity of grain exports is attributed to a sharp decline in grain production, particularly maize during the same period. Maize production declined sharply by over 40% between 2006 and 2007 before accelerating sharply by more than 70% in 2008. Vegetables and nuts increased by 95 000 tonnes in quantity exported in 2008. This can be attributed to the agricultural sector finding new markets or deepening regional integration, as well as the depreciation of the rand in most part of 2008. Meat exports were flat between 2006 and 2008. In 2010 agricultural exports increased steadily until 2014 and declined in 2015.

According to DAFF (2015), exports value amounted to R82.8 billion during the year 2014/15. Agricultural export figures in 2015 which include citrus fruit (R13 804 million), wine (R8 366 million), grapes (R7 499 million), quinces, apples and pears (R6 678 million) also nuts (R3 983 million) those were the major key products which were exported in terms of its value. However, the country's main export crops are table grapes, citrus fruit, pears, apples and wine whereby all those are produced under irrigation condition.

2.6. Agricultural Policies

In terms of agriculture sector is South Africa, there are several policies that were established to support the sector locally and internationally. Among other policies this section covered a few of those policies supporting the sector.

2.6.1 Land Reform Act (1913)

The Land Reform Act was established in 1913 particularly to address the historical injustice on black South African on land removal and the denial of access to their lands. In 1994 South African government opted to divide the land reform act into three policies, those policies consist of: tenure, redistribution and land redistribution. Insecure tenures in most former homelands are addressed by the land tenures. Variety of tenures exists which consists of: (a) personal ownership whereby a land a house is owned by an individual person or business and this must be shown by a registering a title deed for that land or house, (b) in terms of communal ownership by law it is allowed for a group of people or community to own land together lastly (c) renting whereby a person can a rent a house or land from its owner.

As the land redistribution policy covers support services and finances for farmers, the policy is acknowledged as main policy within the land policy in the form of its low interest loans to the farmers. Furthermore, the land redistribution acts as a legal binding process whereby, the community that lost its land due to laws of the apartheid and its practices can verify that they were evicted after the year 1913. Therefore they can reclaim their land or be compensated for the land.

2.6.2 Black Economic Empowerment Act (2003)

The government of South Africa introduced the Agriculture Broad-based Black Economic Empowerment Act AgriBEE (2003) in the year 2003. This act improved the participation of blacks within the sector, this sector started to increase due to its openness to all individuals and businesses. The programme of AgriBEE includes all economic sectors of the country even though the focus is on agro-processing and agriculture.

This Act takes into consideration the provision of codes for good practice. Whereby it indicates the generic development and scorecards of industries, the charter councils' establishment and BEE progress monitor in the industry. In terms of scorecards, they identify the BEE contribution of an enterprise and how it will be measured using the six elements of scorecards. Those elements are organisational transformation, employment equity, ownership, preferential procurement, skills development and management control.

According to this Act, sectors can design their own industry specific scorecards and propose their own charters of BEE. Thus, they are obliged to be in line with the Act's Section 9. Regarding the agricultural sector, it once drafted its own charters however it achieved its section 9 status recently after negotiating for it.

2.6.3 Marketing Act No. 59 (1968)

The Marketing Act (59) of 1968 was introduced by the agricultural marketing system. This policy has replaced the direct controls covers exports and imports within the agricultural sector. It has done so, by exercising its control in terms of tariffs by minimising them below rate bound. This act was initially a control system for quality standards, pricing, selling movement and supplying farms production with large volumes. This was a way of initialising progress and rationalising the tariff regimes and lowering the nominal protection. Nevertheless, the number of control boards involved in South African agricultural products marketing was decreased from 21 in 1993 to 14 in 1997.

Furthermore, in terms of the structure of protection by this act, it affects the agriculture sector. In South Africa, the standard cascades tariff varies from moderately increased rate on consumer products to a reasonable rate on intermediate goods and minimal rate on capital goods.

2.7. Summary

This chapter gave a South African agricultural structure. Firstly, the chapter discussed the structure of agricultural sector, the following section discussed growth trends of the sector along with its ups and downs. Geographical locations of agricultural production were also discussed were it indicated the provinces where agriculture plays crucial role and occupy majority of the land available. Second last, trends of macroeconomic variables were reviewed. Lastly, the chapter focused on agricultural policies supporting agriculture sector of the country.

Having outlined and reviewed trends of agricultural productivity and its impact on macroeconomic variables, the next chapter presents the literature review of the study.

CHAPTER 3

LITERATURE REVIEW

3.1. Introduction

The theoretical perspective is seen as one of reliable base of any research. Therefore, this chapter presents the theoretical and empirical literature review. It includes theories, principles and arguments of past studies in relation to the topic being studied. The chapter is divided into three sections. The first section covers the theoretical perspective of the literature relating to the study at hand, while the second section discusses empirical literature related to the macroeconomics variables impact towards agricultural productivity. The last section summaries the chapter.

3.2. Theoretical Perspective

This part of the study presents the theoretical literature that is related to the macroeconomics variables affecting the agricultural productivity. In a bigger context the macroeconomics variables along with certain factors such environmental factors and technological factors have an impact on agricultural productivity at a national and international context. Moreover, theoretical literature covered in this section is theory supporting agricultural productivity and macroeconomic variables. Among other theories included are Solow growth model, classical theory of marginal productivity and agricultural development models by different economists.

3.2.1 Solow Growth Model

According to Solow (1956), growth accounting framework of neo-classical, states that the output of growth model is the sum of growth in labour and capital accumulation growth, technological progress and productivity growth. Consequently, for a certain factor of inputs combination (capital and labour), the production frontier shift is caused by production improvements.

The emergence occurred in the mid 1980's of new growth theories that reviewed the theory of neoclassical to integrate the technology and be accountable for economic growth determinants that are non-traditional. Therefore, the standard neoclassical growth models of Solow and optimal growth models overlapping generation models have been challenged by theorists of endogenous growth. The technological process has been made endogenous by the endogenous growth models.

According to Molefe (2016), the Solow's growth model when taking into consideration the two factors of production: labour (L) and capital (K) tend to produce a single unit of output. Therefore the Cobb-Douglas form of labour and capital is indicated in the model below:

$$Y_t\ (t) = K(t)\ \big(A\ (t)\ L\ (t)\big)1 - a \tag{3.1}$$

Where t: is period of time

(t): total output produced within specific period for the economy

A: knowledge

AL: labour force.

The growth model of Solow assumes that in production, factors of production must be completely employed. Immediately after the values of K (0), A (0), and L (0) are provided then factors of production are employed completely.

According to Yifru (2015), the theory of Solow focuses on capitalist economy of the class structure. Those classes include land owners, capitalists along with workers whereby each has their individual role in economic process. Capitalists rent the land from land owners and land owners get source of income. Therefore the capitalists employ labour and land for production as the capitalists own the produced means of production. Then labour is owned by workers who sell it on labour market to get wages.

Thus, to increase the production in the sector certainly needs to employ factors of production stated by the Solow growth model. The provision of capital to the sector allows it to be more productive and efficiently as it will be able to purchase all the machinery and pay for the wages of labours. The theory also indicates that availability of land ensures that there is enough space for plantation so that enough agricultural products can be harvested. However, the growth model of Solow (1956) did not explain the technological progress which this results as the weakness of the Solow growth model.

3.2.2 Classical theory of marginal productivity

The marginal productivity theory plays a major part in factor pricing. This classical theory was developed by a Von Thunen a German economist in the year 1826 indicated by Economic discussion (2017). Therefore marginal productivity refers to the raise of output by addition of factors of production by one unit while keeping the other factors constant. Under perfect competition, according to this theory, marginal productivity is equals to the price of rendered service by factors of production.

In addition there is marginal physical productivity, which is the addition toward total production resulting from employing factor of production by one unit (while keeping other things constant). Therefore, to understand thoroughly an example is provided. Suppose one labor can produce six quintals of maize. If addition of one labor is hired, the yield of maize would amount to twelve quintals. In that manner, the marginal physical productivity for extra labor is six quintals of maize. The marginal physical productivity formula is shown below:

$$MPPn = TPPn - TPPn - 1 \qquad (3.2)$$

Where MPP_n: is marginal physical productivity for nth unit of labor

TPP_n: is total physical productivity of n units of labor

TPP_{n-1}: is total physical productivity of n-1 units of labor.

This theory however suffers from certain weakness even though it contributes highly to the factor pricing. It is indicated that the theory is mostly applicable to static economy while on the other hand the economy of the real world is dynamic. It applies on conditions that there is factors of production homogeneity and factors of production perfect mobility. However, in reality, factors of production perfect mobility are not possible. Thus, this makes hard for the theory to applicable in the world. In relation to the study at hand, the theory acts as guidance on how the productivity within the agricultural sector can be increased.

3.2.3 Schultz agricultural development model

Schultz published a book "*Transforming Traditional Agriculture"* in 1964 and in the book he challenged established view made by other development economists. They assumed that farmers in most countries that are developing were unreasonable when coming to innovation. He then argued that, in converse, farmers were making rational responses to low crop prices set by their governments and response to high taxes. Schultz also noted that agricultural extension services that are vital for training farmers in new methods lack in most governments in developing countries. Schultz feels that most of the factors that influence production that are thrift, attitude to work, industriousness and others are not affected by the culture traits of a society.

According to Aditya (2012), people do not save for investment simply, because the method of production does not give a high return. Schultz theory also postulates that people do not work much because the return to labour is rather low. Accumulation of more capital or use of more labour are thus governed by economic factors and not by the cultural factor.

According to Schultz theory traditional agriculture has nothing to do with the institution arrangement in a country. For instance, agriculture in a certain country can become traditional whether it has large farms or small farms. However, people feel that traditional agriculture is associated with a country having a small farm.

Aditya (2012) indicate that if the factors of production are highly productive then its agriculture can be called a modern agriculture. In addition, if the factors of production have low technical efficiency. Thus, it is called a traditional agriculture. However, Schultz theory does not agree with this assertion. In his theory traditional agriculture has some economic feature. If these features appear in agriculture even with technically efficient factors it will become traditional in character. According to him under certain circumstances, even American agriculture which at present is the most advanced agriculture can become traditional.

It is generally felt that resources in a traditional agriculture are not optimally allocated. Hooper (1965) had conducted a study on resource allocation for six classes of farmers in India and found that allocation of resources was not perfect. Schultz's definition does not lead to such a conclusion. On the other hand, it leads one to conclude that resource allocation is perfect in a traditional agriculture.

The argument runs as follows: Art of cultivation remains unchanged (for agriculture to become traditional) and so are the preferences and motives to hold numerous factors of production. Nonetheless, year after year farmers under such circumstances, get the same return (under normal condition), they are bound to adjust their investment in several factors. Yet, such a way limits the marginal productivity of each factor and is finely balanced with its price and this balance will stay if the art of cultivation remains unchanged.

Schultz implication of the Poor but Efficient Hypothesis

- There is no possibility of increasing agriculture production by reallocating the existing resources. The farmers have perfect knowledge about the returns from these resources and are already getting the maximum output from their use. As there is no wasteful utilization of these resources no additional output can be produced if these resources arc reallocated.

- No factor is unemployed in traditional agriculture. The poor but efficient hypothesis also leads to the conclusion that no resources whether capital or labour, are unemployed involuntary. Thus, if any factor, say a labourer is without a job he is so only voluntary. If such a factor demanded employment, it can offer itself in the market. The price of the factor will come down to such an extent that it will be finely absorbed in the production process.

- The hypothesis leads to the conclusion that even in traditional agriculture, there is no dearth of efficient entrepreneurs.

- The hypothesis also implies that farmers in the traditional agriculture are quite responsive to price changes. This is because perfect allocation of resources is not possible unless the producers are too sensitive to price changes. This conclusion is very important because generally it is held that farmers in traditional agriculture are totally insulated from the effects of changes in market forces.

Schultz's Suggestions for Transforming Traditional Agriculture by increasing its production

- Make use of un-utilized resources
- Optimally reallocate the resources to take the production on to the production frontier
- Changes the nature of factors namely replace all or some of the old factor by new ones with higher output-input ratios.

Directly or indirectly, Schultz's ruled out the adoption of first two methods meant for increasing agricultural production. For instance, by his very definition of traditional agriculture, he has concluded that there is no factor of production lying unused in traditional agriculture. Land, labour and other capital assets are fully utilized in traditional agriculture.

Moreover, in the same way he has concluded that resources in agriculture are always perfectly allocated. Hence, the resources were allocated appropriately; there is no prospect to increase production traditionally in agriculture, by further refining the resource allocation. This theory thus, does not recognize the contribution of technological factors. The model has failed to recognize the potential of technological change to increase productivity with the agricultural sector. Furthermore, Schultz theory in South African agriculture plays a role as the agriculture of the country is more of a traditional agriculture with limited improvements. Due to the South African agricultural sector contributing less 3% to the economy one can conclude that the sector is still under traditional agriculture. Nonetheless, the theory supports the sector on how it can increase its productivity in the traditional agriculture.

3.2.4 Mellor's agricultural development model

Mellor's model of agricultural development is yet, another significant contribution to agricultural economics. Mellor's book entitled "*The Economics of Agricultural Development*" established in 1966, two years after Schulz's 'Transforming Traditional Agriculture' was published. Even though in some respect Mellor agrees with Schultz but, comparatively his approach is more pragmatic and extensive in nature. Mellor explains systematically the evolution of agriculture form primitive technology to modern agricultural technology. Mellor believed that along the time path, agriculture undergoes some changes which initiate its transition from tradition to modernity. This model is a basic explanation of agricultural transformation from his traditional character to modernisation. Mellor believes that at any given time, agriculture of a certain economy may be found to be one of the following two phases:

(i) Traditional agriculture.

According to the theory of Mellor, primarily peasant farming of traditional agriculture is characterized by backward labour intensive agriculture ancient methods with low levels of productivity. The sizes of the farms are usually undersized and in the deficiency of other avenues of employment. Thus, similar to the theory of Solow, labour and land are main inputs of traditional agriculture.

(ii) Technologically dynamic agriculture with low capital / labour intensive technology.

Mellor states that when agriculture moves from traditional to technologically dynamic agriculture it can supply resources to grow non-farm sector. Technologically dynamic phase involves the usage of new inputs that has high marginal productivity. However those new inputs do not involve the use of abundant capital. Mellor feels that the following steps are essential if traditional agriculture ought to shift into the second phase of development.

- The changes of institutional to create incentives necessary for development. Mellor believes that changes of institutional like land and reforms are essential for providing incentives to farmers to increase productivity.

- The supply of new and enhanced physical inputs. This is one of the most imperative measures that Mellor suggests for pushing a traditional agriculture into the second phase of development. These inputs include improved breeds of livestock, new crops, inorganic fertilizers etc.

- Set up institutions for agricultural production to be serviced. Several supporting services which should be developed for agricultural production to increase. Those institutions include those facilities marketing agricultural products and those that are distributing modern inputs.

The theory indicates that all those services have to be provided in packages. The theory further points out that the government is the one that has to take those steps rather than individuals.

As conventional the productivity theories have proving to explain the ways on how productivity of the country can be increased. Theories by Schultz and Mellor have indeed considered various considerations to explain categories of which agriculture of a country may fall into. The notable theories which explains the category of the agriculture is explained in the theory of Schultz and Mellor. Thus, the Schultz theory had its shortcoming when it failed to explain thoroughly the technological impact on the productivity of agriculture. The growth model of Solow (1956) was also reviewed whereby it indicates that growth is explained by growth in labour, capital accumulation and technological progress, yet the theory failed to explain the impact of that technological progress.

3.3. Empirical Studies

Among other studies (Lumpur, 2015; Awan, 2014; Ali, Mushtaq and Ashfaq, 2012; Letsoalo and Kirsten, 2003) examined the impact of macroeconomic variables towards agriculture applying varied econometric techniques for different countries. The studies came to different conclusions depending on different countries studied, methodologies and the periods of studies. In addition, this section presents assorted studies conducted relating to the study at hand, methods employed, and the results obtained. This section contains empirical literature from specific countries, group countries and studies conducted for South Africa.

3.3.1 Empirical literature for specific countries

A study by Cristea et al (2015) for the Romanian economy, applied a multiple linear regression approach. Annual data for the period of 1995 to 2014 was used. The study investigated on the macroeconomic variables influencing the performance of agricultural sector in Roman. The study used agricultural share in GDP as dependent variable and macroeconomic variables which included: consumption price index, the consumption price index for food products, the exchange rate (RON/EUR), the interest rate for credits, and the interest rate for deposits, as independent variables. The results revealed a long run relationship among the agricultural component and selected macroeconomic variables.

Lumpur (2015) conducted a study using different approach of cointegration approach which is Engle-granger with annual data from 1981 to 2013. The results established a long run relationship between Nigeria's agricultural output and its independent variables consisting of (interest rate, exchange rate, inflation rate, food import regulator and unemployment rate). The study concluded that interest rate and food import are positively significant variables that affect Nigeria's agricultural output whereas exchange rate, unemployment rate and inflation rate are negatively insignificant. The study furthermore recommended that sufficient financing of agriculture will improve the sector.

Similar to the study of Lumpur (2015), Brownson et al (2012) established a relation between agricultural productivity and selected macroeconomic variables in Nigeria. The study used Engle-granger cointegration approach for its methodology. The cointegration results indicated that there is existence of long-run relationship between agricultural productivity and macroeconomic variables which are total export, inflation rate, nominal exchange rate, industry's capacity utilization rate, real external reserves and agricultural GDP. In addition, agricultural productivity's short run model shows significant negative correlation with external reserve, total exports and inflation rate. The nominal exchange rate, per capita real GDP and industrial capacity utilization are positively correlated. In conclusion, the findings suggest that agricultural sector investment opportunities will be beneficial and will tend to increase agricultural total export.

Muftaudeen and Hussainatu (2014) in their study took different angle compared to Lumpur (2012), by empirically investigating the impact of macroeconomic policy on agricultural output in Nigeria. The study covered a period of 1978 to 2011 Johansen cointegration and Vector Error Correction. The results of the co-integration test based on Johansen's technique showed the existence of co-integration between agricultural output and macroeconomic variables in the Nigeria. The ECM term indicated the possibility of convergence in the long run equilibrium in each period with appropriate sign. Major findings of the study were that, Nigeria's government spending on agricultural sector plays a significant role in achieving food security.

Awan and Alam (2015) investigated the impact of agriculture productivity on economic growth in Pakistan using the Johansen cointegration. The study covered the period from 1972 to 2012 and the data was obtained from World Bank metadata of Pakistan. The variables used were real gross domestic production per capita as a dependent variable and gross capital formation, employed labour force, inflation rate, trade openness, and agriculture value added those were the independent variables. The study concluded that agriculture contributes significantly to economic growth. The study furthermore suggested that the Pakistan government should focus on increasing higher education in agriculture to improve labour force in the agricultural sector.

Ali, Mushtaq and Ashfaq (2012) in their study of Pakistan argued that to have clearer understanding on agricultural productivity, total factor productivity of agriculture and its macro determinants need to be studied. Therefore, to carry out their study they employed Johansen cointegration and VECM approach with annual data from 1971 to 2006. The results presented indicated that openness of agricultural economy and real per capita income was positively associated with total factor productivity of agriculture in the long run. The openness of agriculture economy was found to be positively significant while the variables of real per capita income and inflation were negatively-significant towards productivity in the long run. The results suggested by the study indicated that policies which promote human capital tend to facilitate openness of agricultural economy, improve infrastructural development, and ensure macroeconomic stability and this would lead to higher productivity growth in the long run.

Zainab and Umar (2015) examined the impact of macroeconomic variables on agricultural productivity in Malaysia for the period 1980 to 2014. The autoregressive distributed lag and error correction model were employed. The cointegration test indicated that all variables were cointegrated in the long run. Employing the ARDL it resulted to exchange rate having a negative long-run relationship with agricultural productivity. The study concluded that the performance of agricultural productivity is influenced by macroeconomic variables in the long run. This includes government expenditure, interest rate and net export. These results ensure that agriculture can still play a vital role in contributing to GDP.

Enu and Attah-Obeng (2013) analysed the macroeconomic factors that influence agricultural production in Ghana. Period used covered 1980 to 2011 and the study applied ordinary least squares estimation technique. The study results concluded that apart from inflation, labor force, exchange rate and GDP per capita were all positively significant. Therefore, those macroeconomic variables have a positive impact on agricultural production in Ghana, but except for inflation rate. The study also proposes that the inefficiencies of agricultural sector should be corrected so that farmers can be attracted to the sector.

Gil (2009) study for Tunisia obtained equivalent results while applying different approach. On the study Gil applied VAR framework, as it has been one of the most widely used tools to analyse the dynamic relationships between macroeconomic and agricultural variables. Applying VAR framework, the study has shown that changes in agricultural variables have no significant effects on macroeconomic variables. The main source of responses of the agricultural sector is changes in the monetary policy and specifically, in money supply, which is consistent with how monetary policy is instrumented in Tunisia.

Gil and Kaabia (2000) in their study analysed the effect of macroeconomic variables on agricultural prices and exports in Spain. The Johansen cointegration and Vector Error Correction Model approach was used covering the period of 1978 to 1995 using quarterly data. Results from the long-run analysis indicated that most of the theoretical relationships among macroeconomic and agricultural variables hold. The real quantity of money is neutral with respect to aggregate income.

Bhide, Rajeev and Vani (2005) studied the impact of macroeconomic factors on agriculture in India using the time-series approach. The data used was from 1970 to 2000. The study used two sets of macroeconomic variables which are the price variables: inflation rate, exchange rate and interest rate those formed one set and the second set of macro imbalances included ratio of gross fiscal deficit of GDP and that of current account balance to GDP. Also, three related agriculture variables: agricultural investment, agricultural exports and agricultural real GDP were chosen for measuring the sensitivity of agricultural sector to the macroeconomic conditions. According to the results, the study concluded that the agricultural sector of India is influenced by macroeconomic conditions.

Abba, Barro and Mosca (2015) studied the relationship between macroeconomic determinants and productivity of agriculture. The study was conducted for Mozambique through the usage of Bayesian technique. Results presented by the study showed positive impact of macroeconomic determinants on productivity of agriculture including variables such as GDP, exchange rate and agricultural exports. However inflation, interest rate and government expenditure showed negative impact on agricultural productivity. In conclusion the study suggests that agricultural sector of Mozambique should be considered in the process of macroeconomic policy formulation.

Among the above studies, one can conclude that a study by Lumpur (2015) and Browson (2012) obtained equivalent results, however different methodologies were applied for both studies. Zainab and Umar (2015), Enu and Atta-Obeng (2013) and Abba et al (2015) studied macroeconomic variables and its influence on agricultural productivity. The studies produced mixed results. The results obtained by the study support the expected results of the study at had as the study indicated that interest rate, inflation and real effective exchange rate will have a negative impact on agricultural productivity in the long run so are these three studies.

These studies produced different conclusions mainly due to several variables utilized. Most studies included variables such as inflation, whereby in most studies the variable resulted to having negative relation to agriculture and its productivity in the long run. Variables such as agricultural exports, exchange rates, interest rates, human capital, money supply, GDP and external debt dominated in most studies above. Thus, the study at hand will continue to fill the gap of the above empirical literature by adding other key macroeconomic variables that were not included and attempt to analyze the results using three equations derived from the macroeconomic variables selected and the dependent variable which is agricultural productivity.

3.3.2 Empirical literature for group countries

Dritsakis (2003) examined the relationship between the agricultural sector and macroeconomic environment in EU. Monthly data was used for the period 1982 to 2000. The study employed Johansen cointegration, granger causality and error correction model. The cointegration analysis indicated that there is a long run relationship among variables which are price production, gross national product, exchange rate parity and money supply. Results further showed the existence of positive meaningful relationship between macroeconomic variables and the agricultural sector. These results states that macroeconomics policy decisions are reflected powerfully on agricultural sector therefore they execute an essential role.

Awokuse (2009) investigated the question of whether agriculture could serve as an engine for economic growth using data of 15 developing economies for the period 1971 to 2006. The study conducted by a multivariate ARDL models and error correction model. Variables studied include real GDP per capita, gross capital formation per worker as proxy for capital, labour, agricultural value added per worker, real exports and inflation rate obtained from International Monetary Fund database and World Bank's world development indicators. The study's results indicated that there is long run relationship between agriculture and economic growth. Among other variables gross capital formation in the long run showed positive relation with agriculture in all countries. Yet, inflation appeared to have a negative relation on agriculture.

Awan (2014) on the other hand, focused on investigating main determinant of agriculture productivity growth and their impact on economic growth in seven selected economies and compare their experience with seven advanced countries. Share of employment in agriculture, aggregate labor productivity, intermediate inputs ratio and labor productivity in agriculture formed part of the economic variables. A two-sector model was applied to measure the economic behavior of variables. A time series data was collected from conference board and the total economy database. Results obtained indicate that decline in agricultural productivity in emerging economies and the income gap that is exist between advanced and emerging countries tend to have a negative effect on economic growth in those emerging economies.

Studies relating to this kind of topic are rare. In group countries the study managed to identify limited studies by the works of Dritsakis (2003), Awokuse (2009) and Awan (2014). All the studies did not really engage deep in the topic of study, but they however in relation to the study. Dritsakis (2003) studied the relationship between the agricultural sector and macroeconomic environment in EU. Dritsakis (2003) and Awokuse (2009) results are similar and conclusive as they indicate the long-run relationship among agriculture macroeconomic environment and economic growth. The results are also reminiscent of the ones by Awan (2014. Nonetheless, the results partly support the expected results of the study at hand.

3.3.3 Empirical literature in South Africa

For South African analysis, the study presented by Letsoalo and Kirsten (2003) on macroeconomic importance of trade policies on South African agricultural sector using the two stages least square technique. The study used the secondary data for the period 1981 to 1999 obtained from National Department of Agriculture and South African Reserve Bank. The results of the study concluded that trade policies and macroeconomic variables will stimulate the agricultural sector through output prices. Furthermore, a raise in the degree of openness will have implication for the domestic agricultural sector, either negative or positively.

In terms of studies in South Africa, Greyling (2015) focused greatly on agricultural productivity and economic growth in South Africa. The study covered the period 1970 to 2010 using Engle-granger two step technique. The findings of the study presented indicate that in the long run inflation has a negative relation to agricultural productivity due to the inefficiency of the sector to provide enough main food items. However, the rest of the variables (agricultural exports, labour force, GDP and gross capital formation indicated a positive long run relationship on agricultural productivity. Among other policies derived from the study, the study enhances that there should be a policy framework that is conducive to agricultural marketing and international trade. That policy should limit market distortions and protect the sector so that producers can benefit. Thus, the 1study recommends that it is important that government respond via policy and investment to support the agricultural export mainly the fruit and wine sector within.

Kargbo (2007) argues that agriculture is a competitive sector with prices that are flexible than those of nonagricultural sector. The VECM was applied to investigate the dynamic effect of macroeconomic variables (money supply, inflation rate, exchange rate, money and interest rate) on agricultural sector in South Africa using annual data from 1957 to 2004. The results concluded that money supply, inflation rate, interest rate and real exchange rate are positively significant to agricultural output. The study in addition further concluded that agricultural prices are a source of macroeconomic instability.

Reviewing South African empirical literature regarding agricultural productivity and macroeconomic variables remains an enormous challenge. Studies that were conducted in other countries did manage to analyze the impact of agricultural productivity on various macroeconomic variables. However as for the country of South Africa, there are insufficient empirical studies are presented on the topic at hand. Thus, the rationale of this study is to analyze the impact of agricultural productivity on key macroeconomic variables with the aim of adding to the limited empirical studies that already exist. It is of importance for studies to refocus on agricultural productivity because this sector affects every individual and private and other public sub divisions in diverse ways.

3.4. Summary

In summary, a handful of studies across different views and time period applied Johansen approach. Most of these studies were drawn from other economies since there were limited findings for South Africa at the time of the study. The forth going has shown that macroeconomic policy measures can impact agricultural productivity. However, to the best of our knowledge, limited research works have been carried out to show the impact of agricultural productivity on macroeconomic variables in South Africa. As a result, this study is aimed at closing this gap in the literature by examining the impact of agricultural productivity on macroeconomic variables in South Africa for the period 1975 to 2016.

Both theoretical and empirical literature was reviewed to support the study at hand. The role that agricultural productivity plays towards macroeconomic variables is drawn out of the review. Most of the studies witnessed a positive relationship between macroeconomic variables and agricultural productivity whilst some studies indicated a negative relationship between other macroeconomic variables and agricultural productivity. The empirical literature shows that agricultural productivity can have either negative or positive relationship towards macroeconomic variables it only depends on which variables each study uses. Literature which was reviewed also indicated that agricultural productivity mostly increases in developed countries compared to developing countries states Ramabali et al (2011).

CHAPTER 4

RESEARCH METHODOLOGY

4.1. Introduction

This chapter outlines the analytical framework used in the study. Since the purpose of this study is to specify the macroeconomic variables impacting agricultural productivity in South Africa and identify data used in the model. The chapter is divided into six sections. Section 4.2 specifies the model, section 4.3 provides where data is sourced. Then section 4.4 indicates research techniques then followed by section 4.5 with diagnostic tests. Section 4.6 discusses the granger causality of the study while section 4.7 discusses impulse response. The last section 4.8 is the summary of the chapter.

4.2. Model specification

The study models agricultural productivity as a function of gross domestic product, government expenditure, gross capital formation, real interest rate, money supply, real effective exchange rate, consumer price index and agricultural exports. The study is using three variations of the equations to have different views on how the selected variables impact the agricultural productivity and it uses variety of variables in each equation. In line with this kind of model there has been limited studies conducted in South Africa therefore it is of necessity for this study to be conducted. Moreover, the study adopts the model used by Umar, Kadir and Tunggal (2015). The study modifies their model by using three variations of equations. Therefore, below are reduced forms of econometric model for agricultural productivity:

$$AGRI = \beta_0 + \beta_1 GDP + \beta_2 GE + \beta_3 GCF + \beta_4 RINT + \mu_t \quad (4.1)$$

$$AGRI = \beta_0 + \beta_1 GDP + \beta_2 GE + \beta_3 GCF + \beta_4 REER + \beta_5 AX + \mu_t \quad (4.2)$$

$$AGRI = \beta_0 + \beta_1 GDP + \beta_2 GE + \beta_3 M2 + \beta_4 REER_t + \beta_5 CPI + \mu_t \quad (4.3)$$

Where:
β_0 The intercept
$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$: Explanatory variables coefficients

$\mu_{t:}$ Error term

AGRI: Agricultural productivity, GDP: Gross Domestic Product, GE: Government Expenditure, GCF: Gross Capital Formation, M2: Money Supply, RINT: Real Interest Rate, REER: Real Effective Exchange Rate, CPI: Consumer Price Index and AX: Agricultural exports.

Certain variables are therefore converted into logarithms to obtain the elasticity of coefficients and the outlier effect to be removed. In terms of log linear form, the functions are as follows:

$$AGRI = \beta_0 + \beta_1 LGDP + \beta_2 GE + \beta_3 GCF + \beta_4 RINT + \mu_t \quad (4.4)$$

$$AGRI = \beta_0 + \beta_1 LGDP + \beta_2 GE + \beta_3 GCF + \beta 4LREER + \beta 5LAX + \mu_t \quad (4.5)$$

$$AGRI = \beta_0 + \beta_1 LGDP + \beta_2 GE + \beta 3LM2 + \beta 4LREERt + \beta_5 CPI + \mu_t \quad (4.6)$$

Where *LGDP* is log of gross domestic product, *LREER* is log of real effective exchange rate, *LAX* is log of agricultural productivity and *LM2* is log of money supply.

In terms of expectations of the study, the explanatory variables expectations differ towards agricultural productivity. In all three equations variables such as GDP, GE and GCF are expected to have a positive relation with agricultural productivity resembling the study of Umar and Zainab (2015). Investment of government to the agricultural sector by means of skill development and provision of funds will result to the sector being more efficient and advanced leading to the increase of productivity. Thus, identical to GCF increase in capital expenditure will tend to make the productivity of the sector to produce more output.

However, RINT which is part of equation 4.4 is expected to have a negative relation to agricultural productivity. REER which forms part of equation 4.5 and equation 4.6 is also expected to have a negative relation to the productivity of agriculture similar to the study by Umar and Zainab (2015). Nonetheless, AX which is in equation 4.5 is expected to have a positive relation to agricultural productivity with the rest of variables included in that equation. M2 is expected to have positive relation to agricultural productivity, contrary CPI is expected to have a negative relation to agricultural productivity similar to Brownson, Emmanuel and Etim (2012).

4.3. Data source

The study employs a time series annual data for South Africa for the period of 1975 to 2016. The data was sourced from World Trade Organization, World Bank, DAFF and Quantec. Variables used for this study are agricultural productivity as the dependent variable and agricultural exports, real effective exchange rate, gross domestic product, government expenditure, gross capital formation, real interest rate, consumer price index and money supply being independent variables. Some of the variables are expressed as percentage and some are subjected to natural logarithms as they are in their estimated values. Below table summaries all variables included for analysis in the study and their sources of data:

Table 4.1: Summary of data sources

Variables	**Indicator name**	**Measurement**	**Source of dataset**
AGRI	Agricultural productivity	% of GDP	World bank & DAFF
AX	Agricultural exports	Rand value	World trade organization
REER	Real effective exchange rate	Rand currency	Quantec
GCF	Gross capital formation	Annual %	Quantec
GDP	Gross domestic product	Rand value	Quantec
GE	Government expenditure	Annual %	Quantec
INT	Real interest rate	Annual %	World bank
CPI	Consumer price index	Annual %	World bank
M2	Money supply	Rand value	Quantec

4.4. Estimation techniques

For econometric analysis there are various estimation techniques available to use. This study applies the cointegration in multiple equations which can be examined using Johansen (1981) and Johansen Juselius (1990) approach. The Johansen approach of cointegration gives two statistics. These are the value of LR test based on the trace value of the stochastic matrix and maximum Eigen-value. The likelihood ratio is used to test Johansen cointegration. Up to (r-1) co-integrating relationships may exist between a set of r variables. When number of cointegrating relationships is greater than or equal to one the hypothesis of cointegration is accepted. This approach is also known for its long-run relationship establishment between variables.

The Johansen statistic is also adopted to resolve the issue of endogeneity of explanatory variables by allowing error correction model with lag restrictions. It is chosen as it can test multiple cointegration vectors. The VECM is used to determine the long run and short run determinants of the dependent variable in the model. The Johansen technique therefore compromises of the following steps:

Step 1: All variables to be integrated of the same order before moving to the cointegration test.

Step 2: The correct lag length of the model to be determined. Furthermore, in this step is the estimation of the model and the determination of the rank of Π.

Step 3: Analysis of the normalized co-integrating vector(s) and speed of adjustment coefficients is determined.

Step 4: This step determines the number of co-integrating vectors. Thereafter causality test on the VECM is applied to identify a structural model and determine whether the estimated model is reasonable.

In the following section unit root tests are discussed to test stationarity of the data. Augmented Dickey-Fuller and Phillip-Perron unit root tests are employed to investigate the unit root properties of the time series data.

4.4.1 Augmented dickey-fuller unit root test

The unit root test is important as it examines whether there is stationarity in time series or not. Problem of unit root can be solved by differencing it if it did not obtain stationarity at levels Wei (2006). This would be written as I (*d*). Applying the difference operator more than *d* times to an I(*d*) process will still result in a stationary series (but with an MA error structure). An *I (0)* series is a stationary series, while an *I(1*) series contains one-unit root. An *I (2)* series contains two-unit roots and so would require differencing twice to induce stationarity. *I (1)* and *I(2*) series can wander a long way from their mean value and cross this mean value rarely, while *I(0)* series should cross the mean frequently Choga (2008).

The existence of a time series to be stationary is important for some reasons main. First, the stationarity of a series can influence the conduct and properties, for instance, persistence of shocks will be infinite for non-stationary series. Secondly, if two variables are trending over time, a regression of one, on the other hand, could have a high even if the two are totally unrelated and this is known as spurious regressions. Thirdly, if the variables in the regression model are not stationary, then it can be proved that the standard assumptions for asymptotic analysis will be invalid Dickey and Fuller, (1979).

The Augmented Dickey-Fuller test estimates the following equation:

$$\Delta Y_t = a + \beta_t + \delta Y_{t-1} + \sum_{i-1}^{n} \lambda \Delta Y_{t-1} + \mu_t \qquad (4.7)$$

Where Δ is a first difference operator, y_t is the relevant time series, t is a linear trend and μ_t is the error term.

The null and alternative hypothesis of the ADF is formulated as follows:

H_O: The series has a unit root (Non-Stationary)

H_1: The series does not have a unit root (Stationary)

4.4.2 Phillips-Perron test

Perron (1986) states that the P-P test is non-parametric unit root test that is modified so that asymptotic distribution is not affected by serial correlation. P-P test reveal that all variables are integrated of order one with and without linear trends, and with or without intercept terms. Thus, it is used in time series analysis to test the null hypothesis that a time series is integrated of order 1.

The test also builds on the Augmented Dickey–Fuller test of the null hypothesis:

$$\rho = 1 \; in \; \Delta y_t = p y_{t-1} + u_t \tag{4.8}$$

Where Δ is the first difference operator. Like the Dickey–Fuller test, the Phillips–Perron test addresses the issue that the process generating data for y_t might have a higher order of autocorrelation than is admitted in the test equation, which makes y_{t-1} endogenous. Whilst the augmented Dickey–Fuller test addresses this issue by introducing lags of Δy_t as regressors in the test equation, the Phillips–Perron test makes a non-parametric correction to the t-test statistic. The test is robust with respect to unspecified autocorrelation and heteroscedasticity in the disturbance process of the test equation.

The null and alternative hypotheses of PP may be written as follows:

$H_{O:}$ The series has a unit root (Non-Stationary)
$H_{1:}$ The series does not have a unit root (Stationary)

Therefore accepting the null hypothesis implies that there is a unit root (the series is non-stationary) whereby rejecting the null hypotheses implies that there is no unit root (the series is stationary).Furthermore the null hypothesis of a unit root is rejected if the t-statistic associated with the estimated coefficients exceeds the critical values of the test.

4.4.3 Determination of lags length

Lags length selection is determined using different measures such as Final Prediction Errors (FPE), Akaike Information Criteria (AIC), Schwartz Bayesian Information Criteria (SBIC) and Hanna and Quinn Information Criteria (HQIC). According to Liew (2004), Akaike Information Criteria (AIC) and Final Prediction Errors (FPE) are most dependable and used criterions for the study that has 60 observations or below.

4.4.4 Cointegration Test

The generalization of cointegration test is to examine linear combination for stationarity. When there is existence of more than one two variables, the Johansen cointegration is employed to estimate cointegration vectors. If three variables with unit root exist it is likely that there are at most two cointegrating vectors existing. In general, if n variables have unit roots, there are at most cointegrating vectors present. Therefore all cointegration vectors are estimated using the Johansen cointegration test.

In terms of the Johansen cointegration test to be applied, the following equations are used:

Trace test

$$\lambda trace(r) = -T \sum ln(1 - \lambda_1) \tag{4.9}$$

Maximum eigenvalue test

$$\lambda max\,(r, r\ +\ 1)\ =\ -\,T \sum ln\,(1 -\ \lambda_{r+1}) \tag{4.10}$$

Where λ_{r+1}..., λn are estimated eigenvalues. In these two tests trace and maximum eigenvalue, λ represents estimated values obtained from the estimated Π matrix, and T represents the sample size. Trace test attempts to test the null hypothesis of r cointegrating vectors between the variables against cointegrating vectors of n alternative hypothesis. On the other hand, the maximum eigenvalue test tests the null hypothesis of r cointegrating vectors against the alternative hypothesis of r +1 cointegrating vectors.

4.4.5 Vector Error Correction Model

After ascertaining co-integrating relationship existence, the vector error correction model is estimated to test dynamics of the short run. The Johansen approach considers the starting point of VAR of order P by the following:

$$Y_t = A_1 Y_{t-1} + \cdots A_p Y_{t-p} + \beta x_t + \varepsilon_t \quad (4.11)$$

Therefore, to apply the Johansen test, VAR needs to be transformed into VECM model and be written as:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma i \Delta Y_{t-1} + \beta x_t + \varepsilon_t \quad (4.12)$$

Where

$$\Pi = \sum_{i=1}^{p} Ai\text{-}1 \text{ and } \Gamma i = -\sum_{j}^{p} = i+1Aj \quad (4.13)$$

If the coefficient matrix Π has reduced rank r < k then there exists k x matrices α and β each with rank *r* such that π = αβ' and $\beta' y_t$ is I(0). *R* is the number of cointegrating relationships, the elements of α are known as the adjustment parameters in the vector error correction model and each column of β is a cointegrating vector. It can be shown that for a given *r*, the maximum likelihood estimator of β defines the combination of y_{t-1} that yields the *r* largest canonical correlations of Δy_t with y_{t-1} after correcting for lagged differences and deterministic variables when present.

4.5. Diagnostic tests

This section indicates diagnostic tests to be conducted by the study. The diagnostic tests are conducted on the error-correction model to verify whether any of these assumptions have not been violated. The study employs the following diagnostic tests:

4.5.1 Heteroskedacity

According to Engle (1982), the Langrange multiplier is used to test the heteroscedasticity which is also known as the Engle's Arch LM test. The sequence that has random variables with different variance results to heteroscedasticity. The procedure of the test is shown below:

H_0: There is no heteroscedasticity.
H_1: There is heteroscedasticity.
Test statistic is as follows:
$LR = nR^2$

Whereby n is observations number, and R^2 is the coefficient of determination of the augmented residual regression.

Therefore the null hypothesis is rejected if the p-value ≤ level of significance concluding that there is heteroscedasticity.

4.5.2 Residual normality test

The normality distribution of the VECM is tested using the Jacque-Bera test. It is a commonly used test for normality. This test measures the difference in kurtosis and skewness of a variable compared to those of the normal distribution (Jarque and Bera, 1990). The JB also uses the property of a normally distributed random variable that the entire distribution is characterised by the mean and the variance. The hypothesis of Jacque-Bera test is as follows:

H_0: The variable is normally distributed.
H_1: The variable is not normally distributed.

The test statistic is:

$$JB = \frac{N-K}{6}\left[S^2 + \frac{(K-3)^2}{4}\right] \qquad (4.14)$$

Where N is observations number, k is estimated parameters number, S is the skewness of a variable, and K is the kurtosis of a variable.

The null hypothesis is rejected if the p-value ≤ level of significance, or if the JB > x^2.

4.5.3 Stability test

The stability test of this study will be tested using the AR Roots graph. The graph reports the inverse roots of the characteristic AR polynomial. The VAR estimated is stable if all the roots have less than one modulus and lie within the unit cycle. Thus, if VAR is not stable then results obtained from the impulse response may not be valid.

4.6. Granger causality

According to Granger (1969), X variable granger-causes Y variable if the past changes of X could assist in predicting Y current changes. Brook (2002) extends by saying if X variable granger-causes Y variable and not the other way round, that is called unidirectional causality. However if X variable granger causes Y variable and vice versa, that is called a bi-directional causality between the variables. The variables need to be stationary for causality test to be applied.

A simple casual model can be expressed as follows:

$$X_t = \sum_{j=1}^{m} a_j \ x_{t-j} + \sum_{j=1}^{m} b_j y_{t-j} + \varepsilon_t \tag{4.15}$$

$$Y_t = \sum_{j=1}^{m} c_j \ x_{t-j} + \sum_{j=1}^{m} b_j y_{t-j} + n_t \tag{4.16}$$

The causality explanation given above implies that *Yt,* is granger causing *Xt* provided b_j is not zero. In the same way as *Xt* is granger causing Yt if c_j is not zero. If both events occur, then there is causality between *Xt* and *Yt*.

The hypothesis for Granger Causality test can be expressed as follows:

H_O: X_t *does not cause* Y_t

H_1: X_t *cause* Y_t

The granger causality test represents only a relationship between the current value of one variable and the previous values of the other variable. The test does not denote that movements of one variable cause movements of another variable (Brooks 2002). Moreover, although causality in VAR examines whether the current value of variable X can be explained by the past values of variable Y, it still does not clarify the sign of the relationship.

4.7. Impulse response analysis

Singla and Beag (2014), states that in most cases granger causality test fails to determine strength of effect for causality beyond the time span selected. As causality tests are unable to show existing feedback from variables, then the granger causality test are inappropriate. Hence, impulse response is considered as it is the favored way in interpreting models of implications for transmission patterns along with adjustments and causality. This is to consider the time span of variable after the exogenous shocks, whereby in this study, agricultural productivity is shocked towards selected macroeconomic variables.

Sun and Xu (2010) indicated that, the higher correlations between the residuals the more important the variable ordering is. Thus, Pesaran and Shin (1998) to overcome that problem, they introduced functions of generalized impulse response, whereby it adjusts the control of various order of variables on impulse response functions. Regarding this study the generalized impulse response is applied by plotting patterns of historical correlations.

4.8. Summary

This chapter presented the analytical framework that is used to analyse macroeconomic variables towards agricultural productivity for South Africa. The dependent variable for the study is agricultural productivity followed by independent variables which are gross domestic product, government expenditure, gross capital formation, real interest rate, money supply, real effective exchange rate, agricultural exports and consumer price index. The choice of the variables was influenced by the importance of those variables towards agricultural productivity and the availability of data.

The chapter describe where data was sourced, also model specification and the period analysed which is from 1975 to 2016 using time series data. Econometrics techniques of which the study is using it is explained, among others are: Augmented–Dickey Fuller and Phillips-Person to test for unit root, followed by Johansen cointegration to test long run relationship among variables. In addition, diagnostic checks are done which includes; normality test, serial correlation and heteroskedasticity along with stability test to see whether the residual of the series passes all these diagnostic checks. Granger causality and impulse respond are also checked. The following chapter apply the specified model and techniques presented in this chapter for the results and interpretations to obtain the objectives of the study.

CHAPTER 5

RESULTS AND DISCUSSION

5.1. Introduction

The findings of this study explain how macroeconomic variables impact agricultural productivity in South Africa. The period covered is from 1975 to 2016. Methodology presented in chapter four is applied in this chapter. The equations in this chapter which is equation 4.4, 4.5 and 4.6 represent equations derived in chapter 4 of methodology. Therefore this chapter consists of eight sections. Firstly section 5.2 presents the descriptive statistics along with the unit root test results, followed by lag length criteria selection in section 5.3. Section 5.4 provides Johansen cointegration tests results which lead to the formulation of VECM in section 5.5. The diagnostic tests results are followed in section 5.6 and granger causality results in section 5.7 along with impulse response in section 5.8. Lastly section 5.9 presents the summary of the chapter.

5.2. Unit root test results

Often macroeconomics time series data are generally characterised by a stochastic trend which can be eliminated by differencing the series. Firstly, in Johansen procedure, time series data is tested for stationarity of all variables. To begin with the study analysis the descriptive statistics of the variables as it is important for every econometric analysis. Therefore the next part of the study examines the order of integration by applying the graphical illustrations which is an informal test and formal two tests namely Augmented Dickey Fuller and Phillips-Perron.

The study presents the graphical illustrations. According to Choga (2008) the graphical illustrations are necessary as they allow for detection of errors of data captured. Those graphical illustrations also check structural breaks that may bias tests of unit root. However, with those graphics alone assurance cannot be met about the status of stationary on variables that might appear to have a clear trend regarding this study.

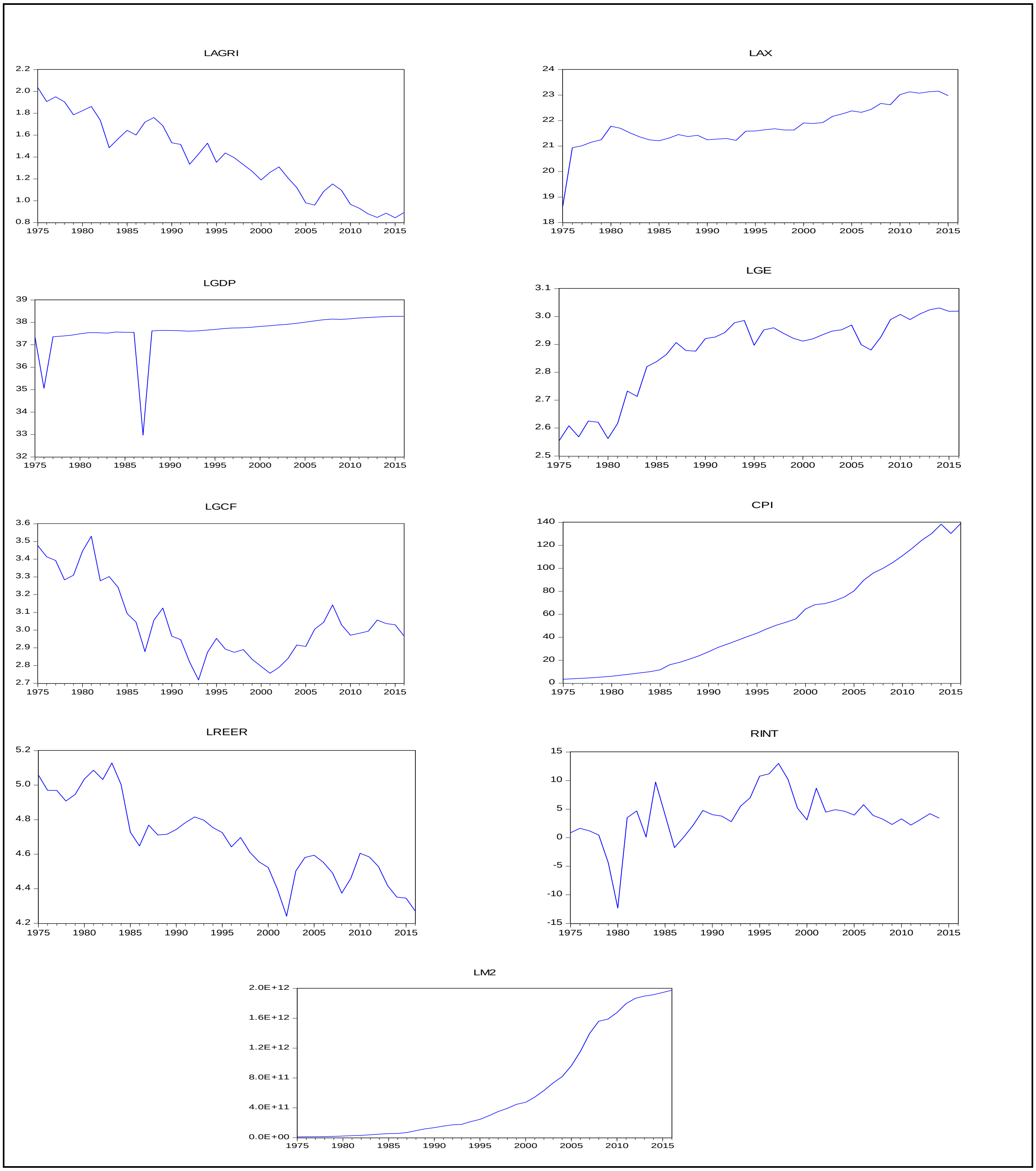
In regard to the formal tests, ADF and PP tests are employed which tests the null hypothesis of a unit root against the alternative of no unit root. The calculated value of both tests is then compared with the critical values. Nonetheless, if the value calculated is greater than the critical values the study reject the null hypothesis that states that the series has a unit root which confirms that the series is stationary.

Below table 5.1 shows the descriptive statistics of variables used in the study. Figure 5.1 and 5.2 presents graphical illustrations of all the variables under study. Figure 5.1 shows graphs of 7 variables in logarithm form and 2 variables (CPI and RINT) already in percentages and figure 5.2 shows variables being differenced. Table 5.2 and table 5.3 presents the results of ADF and PP unit root test. Whereby some of the variables are in logarithm and other variables are already in percentages. The series tested in (a) intercept, (b) trend and intercept and (c) without intercept and trend.

Table 5.1: Descriptive statistics for time series data of South Africa

	AGRI	AX	REER	GCF	GDP	GE	RINT	CPI	M2
Mean	1.387	21.787	4.682	3.045	37.620	2.872	3.746	54.346	26.141
Median	1.373	21.634	4.672	3.000	37.707	2.921	3.848	45.366	26.319
Maximum	2.035	23.155	5.128	3.530	38.275	3.030	13.012	138.900	28.312
Minimum	0.844	18.643	4.241	2.719	32.976	2.555	-12.315	3.427	23.103
Std.Dev.	0.350	0.833	0.236	0.210	0.892	0.143	4.345	44.067	1.709
Skewness	0.055	-0.817	0.135	0.717	-3.987	-1.119	-0.895	0.520	-0.295
Kurtosis	1.871	6.292	2.171	2.598	20.092	2.934	6.571	1.979	1.793
Jarque-Bera	2.249	23.080	1.330	3.883	622.549	8.778	26.590	3.716	3.159
Probability	0.325	0.000	0.514	0.144	0.000	0.012	0.000	0.156	0.206
Sum	58.20	893.30	196.67	127.90	1580.04	120.64	149.85	2282.54	1097.9
Sum Sq.Dev	5.02	27.75	2.28	1.81	32.63	0.84	736.34	7967.40	119.71
Observations	42	42	42	42	42	42	42	42	42

Figure 5.1: Graphical illustrations of variables in levels for the period of 1975 to 2016



According to the above graphical illustrations, figure 5.1 indicates that AGRI, REER and GCF show a downward trend. The CPI, M2 GE and AX shows a growth trend throughout the years whilst RINT behavior fluctuating up and down through the period of 1975 to 2016. In terms of GDP there's been a slight increase through the years, however during 1987 it indicated a massive down trend but then after that it showed an upward trend. The series in levels appears to be non-stationary with all its trendy behavior.

Figure 5.2: Graphical illustrations of variables in first difference for period of 1975 to 2016

Figure 5.2 shows the series after being first differenced. The graphical illustrations presented show the stationarity of the variables compared to when they were on levels. As the series is integrated in order one it ensures that the data is stationary and spurious regression will be avoided. However informal method alone cannot be relied upon, therefore the formal tests of ADF and PP are applied below.

Table 5.2 Unit root results of the Augmented Dickey Fuller test

Variables	Formula	ADF			
		Levels	**5% Critical value**	**1st difference**	**5% Critical value**
LAGRI	Intercept	-1.312	-2.935	-5.368**	-2.943
	Trend & intercept	-5.079**	-3.533	-5.293**	-3.524
	None	-2.199**	-1.949	-6.111**	-1.950
LAX	Intercept	-4.451**	-2.937	-14.923**	-2.939
	Trend & intercept	-7.008**	-3.527	-14.364**	-3.530
	None	1.626	-1.949	-14.490**	-1.950
REER	Intercept	-1.191	-2.935	-5.431**	-2.937
	Trend & intercept	-3.823**	-3.527	-5.364**	-3.527
	None	-1.368	-1.950	-5.340**	-1.949
GCF	Intercept	-2.383	-2.935	-6.447**	-2.937
	Trend & intercept	-2.085	-3.524	-6.520**	-3.527
	None	-1.429	-1.949	6.423**	-1.949
GDP	Intercept	-5.173**	-2.935	-7.315**	-2.939
	Trend & intercept	-6.845**	-3.524	-7.219**	-3.530
	None	0.516	-1.950	-7.365**	-1.950
GE	Intercept	-1.875	-2.935	-6.905**	-2.937
	Trend & intercept	-2.026	-3.524	-6.937**	-3.527
	None	-1.482	-1.950	-6.535**	-1.949
RINT	Intercept	-3.324**	-2.939	-6.698**	-2.943
	Trend & intercept	-3.466	-3.530	-6.621**	-3.537
	None	-2.321**	-1.950	-6.792**	-1.950
CPI	Intercept	-4.926**	-2.935	-3.528**	-2.937
	Trend & intercept	0.120	-3.524	-5.291**	-3.527
	None	-1.578	-1.949	-1.286	-1.950
M2	Intercept	-2.521	-2.937	-2.906	-2.937
	Trend & intercept	0.996	-3.530	-3.968**	-3.527
	None	2.137**	-1.612	-1.481	-1.950
Notes: Reported values under levels and first difference are ADF t-statistics values * Statistically significant at 1% level ** Statistically significant at 5% level *** Statistically significant at 10% level					

Table 5.2 above shows results obtained from the Augmented Dickey-Fuller test. According to this test at levels, GCF and GE and are non-stationary at all equations while CPI is non-stationary at trend & intercept and none. The remaining variables appeared to be stationary in more than one equation in levels concluding that those variables perform better than other variables. Nonetheless the variables were further differenced at first difference to totally reject the null hypothesis that indicates that there is existence of unit root. All the variables after

differencing they became stationary, concluding that the variables are integrated of order I (1) and null hypothesis of unit is rejected.

Table 5.3 Unit root results of the Phillips-Perron test

Variables	Formula	PP			
		Levels	**5% Critical value**	**1st difference**	**5% Critical value**
LAGRI	Intercept	1.275	-2.935	-11.006**	-2.937
	Trend & intercept	-3.746**	-3.524	-10.740**	-3.527
	None	-5.146**	-1.950	-6.173**	-1.949
LAX	Intercept	-3.993**	-2.937	-15.064**	-2.939
	Trend & intercept	-6.096**	-3.527	-14.364**	-3.530
	None	-1.623	-1.949	-13.524**	-1.950
REER	Intercept	-0.973	-2.935	-5.905**	-2.939
	Trend & intercept	-3.059	-3.524	-5.735**	-3.527
	None	-2.137**	-1.949	-5.306**	-1.949
GCF	Intercept	-2.371	-2.935	-6.551**	-2.937
	Trend & intercept	-2.025	-3.524	-7.520**	-3.527
	None	-1.738	-1.949	-6.551**	-1.949
GDP	Intercept	-5.177**	-2.935	-24.180**	-2.937
	Trend & intercept	-6.918**	-3.524	-25.654**	-3.527
	None	0.682	-1.950	-19.269**	-1.949
GE	Intercept	-1.911	-2.935	-6.905**	-2.937
	Trend & intercept	-1.996	-3.524	-7.018**	-3.527
	None	-1.482	-1.950	-6.544**	-1.949
RINT	Intercept	-3.322**	-2.939	-8.599**	-2.941
	Trend & intercept	-3.496	-3.530	-8.513**	-3.533
	None	-2.187**	-1.950	-8.734**	-1.950
CPI	Intercept	-4.346**	-2.935	-3.444**	-2.937
	Trend & intercept	0.038	-3.524	-5.266**	-3.527
	None	2.967**	-1.619	-1.496	-1.949
M2	Intercept	-2.919	-2.935	-2.864	-2.937
	Trend & intercept	1.956	-3.524	-3.701**	-3.527
	None	6.446**	-1.949	-1.266	-1.949

Notes: Reported values under levels and first difference are ADF t-statistics values
* Statistically significant at 1% level
** Statistically significant at 5% level
*** Statistically significant at 10% level

Table 5.3 above shows the results obtained from Phillips-Perron test. According to Brook (2008) Phillips Perron test is similar to the one of Augmented Dickey-Fuller test. The results reflected that GCF and GE are non-stationary at all levels, while M2 and REER are non-stationary on intercept and trend & intercept. RINT and CPI are non-stationary at trend & intercept. The series was differenced further at first difference whereby all variables were stationary. The results concluded that the null hypothesis of the unit root is rejected.

In both methods of ADF and PP that were employed to test stationarity indicated that both series were partly non-stationary at levels however after those series were differenced they became stationary. Overall it can be concluded that order of integration for all series in ADF and PP are in mixed order as they are integrated of order zero and order one.

5.3.Lag order selection criteria

The study uses the information criteria approach to carefully select the lag length order. This is part of the Johansen approach requirements to indicate the order of lags and its deterministic trend assumption of VAR. Table 5.4, 5.5 and 5.6 below indicates the lag lengths selected for each order with different information criterion.

Table 5.4 Lag length selection for Equation 4.4

Lag	Log L	LR	FPE	AIC	SC	HQ
1	20.934	NA	8.64e-07*	0.220*	2.883	1.473
2	36.945	23.368	1.49e-06	0.706	1.308*	0.603*
3	54.318	20.660	2.69e-06	1.118	4.383	2.269

Notes

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 5.5 Lag length selection for Equation 4.5

Lag	Log L	LR	FPE	AIC	SC	HQ
1	25.925	NA	6.96e-08*	0.530*	2.082*	1.082*
2	51.868	35.501	1.33e-07	1.060	4.162	2.164
3	81.102	30.773	2.72e-07	1.416	6.070	3.072

Notes

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 5.6 Lag length selection for Equation 4.6

Lag	Log L	LR	FPE	AIC	SC	HQ
1	87.667	NA	2.89e-09	-2.650	-1.140*	-2.099*
2	132.349	61.867*	2.06e-09*	-3.095*	-0.024	-1.992
3	165.607	35.817	3.30e-09	-2.954	1.653	-1.301

Notes

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 5.4 confirms the criteria selected in equation 4.4 which chooses lag length 2 and table 5.5 for equation 4.5 selected lag length 1 and lastly table 5.6 confirms the lag length selection of 2 for equation 4.6 therefore the Johansen cointegration test was conducted using the lags length selected for each equation.

5.4.Johansen cointegration results

Since the ADF and PP tests demonstrated stationarity of variables. It is essential to determine whether long-run relationship exists among those variables. Cointegration is mostly used to determine the existence of equilibrium relation between two or more-time series. For this study cointegration is utilised to determine the long-run relationship between agricultural productivity and selected macroeconomic variables. For prominent economic conclusion to be made, it is crucial to assess the existence of long-run relationship and use those results to conclude accurately. The Johansen cointegration approach is used and the results are as follows:

Table 5.7 Johansen Co-integration test results for Equation 4.4

		Trace statistics		**Maximum eigenvalue statistics**	
Hypothesis Number of CE	Eigenvalue	Trace Statistics	0.05 critical value	Maximum-eigenvalue Statistics	0.05 critical value
None	0.647	93.445**	88.804	38.517**	38.331
At most 1	0.390	54.927	63.876	18.319	32.118
At most 2	0.361	36.608	42.915	16.568	25.823
At most 3	0.268	20.041	25.872	11.555	19.387
At most 4	0.205	8.486	12.518	8.486	12.518

Trace test indicates 1 cointegrating equation(s) at the 0.05 level
Max-eigenvalue test indicates 1 cointegrating equation(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

Table 5.7 for equation 4.4 which included LAGRI, LGDP, GCF, GE and RINT as its variables shows trace and maximum eigenvalue results from order one of variable. The trace test reflects that there is at least one co-integrating equation that exit at 5% level of significant. The null hypothesis of no cointegrating vectors is rejected since the trace statistics of 93.444 is greater than 5% critical value of 88.803. Even on the maximum eigenvalue test there is existence of one cointegrating vector.

Table 5.8 Johansen Co-integration test results for Equation 4.5

		Trace statistics		**Maximum eigenvalue statistics**	
Hypothesis Number of CE	Eigenvalue	Trace Statistics	0.05 critical value	Maximum-eigenvalue Statistics	0.05 critical value
None	0.684	137.736**	117.708	44.902**	44.497
At most 1	0.644	92.833**	88.804	40.279**	38.331
At most 2	0.440	52.554	63.876	22.641	32.118
At most 3	0.309	29.912	42.915	14.419	25.823
At most 4	0.205	16.493	25.872	8.938	19.387
At most 5	0.155	6.555	12.518	6.555	12.518
Trace test indicates 2 cointegrating equation(s) at the 0.05 level Max-eigenvalue test indicates 2 cointegrating equation(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level					

Table 5.8 for equation 4.5 used LAGRI, LAX, LREER, GCF, GE and LGDP and RINT as variables, in both trace and maximum eigenvalue tests indicated two cointegrating vector. The results show that they are significant at 5% level. It can therefore be concluded that equation 4.5 has a long run equilibrium relation with at least two cointegrating vector in each equation. In this order the null hypothesis of no cointegration is rejected.

Table 5.9 Johansen Co-integration test results for Equation 4.6

		Trace statistics		**Maximum eigenstatistics**	
Hypothesis Number of CE	Eigenvalue	Trace Statistics	0.05 critical value	Maximum-eigenvalue Statistics	0.05 critical value
None	0.832	161.428**	117.708	69.560**	44.497
At most 1	0.578	91.868**	88.804	33.602	38.331
At most 2	0.523	58.266	63.876	28.885	32.118
At most 3	0.307	29.380	42.915	14.322	25.823
At most 4	0.234	15.058	25.872	10.419	19.387
At most 5	0.112	4.638	12.518	4.638	12.518
Trace test indicates 2 cointegrating eqn(s) at the 0.05 level Max-eigenvalue test indicates 1 cointegrating equation(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level					

Table 5.9 using LAGRI, CPI, LGDP, GE, LREER and M2 for equation 4.6 shows that trace test reflects to be having two cointegrating vectors at 5% level of significant similar to equation 4.5, however equation 4.4 indicated 1 cointegrating vector for trace test. This kind of results for equation 4.6 has been influenced by CPI and M2 whereby in equation 4.4 and equation 4.5 those two variables do not exist. Maximum eigenvalue test only showed one cointegrating vector among variables which that result is identical to maximum eigenvalue of equation 4.4.

In all three equations there is existence of a long run relationship among those variables established between equation 4.4, equation 4.5 and equation 4.6. Therefore the short run and long run dynamics of those equations can be established with Vector Error Correction Model.

5.5. Vector error correction model (VECM)

The Vector Error Correction Model technique allows capturing of dynamics for long-run and short-run in a single step. In this case the dynamics of agricultural productivity in the short-run and investigate its adjustment speed parameter and how it responds to long-run equilibrium after random shock. The following table 5.10 includes the long-run and table 5.11 includes short-run results of VECM for all three equations.

Table 5.10 Long-run parameters results

ORDER	Equation 4.4	Equation 4.5	Equation 4.6
	Coefficient	*Coefficient*	*Coefficient*
CONSTANT	5.92	2.034	37.81
TREND	0.038 (11.352)	0.031 (6.676)	0.059 (3.887)
Variables			
LGDP	0.084 (2.258)*	-0.029 (-1.547)	0.386 (7.996)*
GE	1.212 (3.326)*	0.134 (0.613)	3.364 (6.598)*
GCF	0.475 (2.621)*	-0.147 (-1.127)	-
RINT	0.004 (0.862)	-	-
LM2	-	-	0.835 (4.168)*
LREER	-	-	-0.004 (-2.798)*
CPI	-	-	-1.452 (-5.880)*
LAX	-	0.055 (0.921)	-

Notes: Values in brackets are t-statistics
* Statistically significant at 1% level
** Statistically significant at 5% level
*** Statistically significant at 10% level

The long-run equation is estimated to determine if whether there is positive or negative relation between the variables. In equation 4.4, it reflects that a 1% increase in GDP will lead to a 0.008 increase in agricultural productivity in the long-run. Furthermore a 1% increase in GE will lead to a 1.212 increase in agricultural productivity. In addition an increase of 1% in GCF will lead to a 0.475 increase in agricultural productivity. Lastly, a 1% increase in RINT will lead to 0.004 increases in agricultural productivity. All the variables of this equation show a positive relationship in the long-run with agricultural productivity.

A 1% increase in GDP for equation 4.5 will lead to -0.029 decreases in agricultural productivity. Also 1% increase in GCF will lead to -0.147 decreases in agricultural productivity. This indicates that GDP and GCF has a negative relationship with agricultural productivity in the long-run.

Whilst on the other hand, 1% increase in GE will lead to a 0.134 increase in agricultural productivity. Furthermore a 1% increase in AX will lead to 0.055 increase in agricultural productivity. These results suggest that the more productivity there is in agricultural sector the greater outputs will be produced leading to more agricultural products being exported.

In addition to equation 4.5, restrictions were imposed as there were existence of more than one cointegrating vectors. The two cointegrating vectors that were established are shown in the following equation:

$$\Pi z_{t-1}=\alpha\beta^{1}z_{t-1}=\begin{bmatrix} a11 & a12 \\ 0 & 0 \\ 0 & 0 \\ a41 & a42 \\ a51 & a52 \\ a61 & a62 \\ a71 & a72 \end{bmatrix}\begin{bmatrix} 1 & 0 & _{\beta}31 & _{\beta}41 & _{\beta}51 & _{\beta}61 \\ 0 & 1 & _{\beta}32 & _{\beta}42 & _{\beta}52 & _{\beta}62 \end{bmatrix}\begin{bmatrix} LAGRIt-1 \\ REERt-1 \\ LAXt-1 \\ LGCFt-1 \\ LGDPt-1 \\ LGEt-1 \\ Constant\ t \end{bmatrix} \quad (5.1)$$

In the first cointegrating vector, long-run zero restriction were imposed on real effective exchange rate as it is a dependent variable in the second cointegrating vector. Followed by zero restriction impose on agricultural productivity as it is dependent variable in the first cointegrating vector. The restrictions imposed indicate that real effective exchange rate does not play a vital a role in determination of agricultural productivity in South Africa. This implies that we can have agricultural productivity equation without real effective exchange rate. In second equation we can have real effective exchange rate equation without agricultural productivity. This shows that the two variables do not play a significant role in determination of another variable.

The first long-run cointegration vector equation can be written as:

$$LAGRI= 0.649LAX+3.065\ GCF+1.469LGDP+4.890GE-99.873 \quad (5.2)$$

In the long-run a 1% increase in AX increases agricultural productivity by 0.649. An increase of 1% in GCF will lead to an increase of agricultural productivity by 3.065 percent and an increase by 1% in GDP will lead to an increase of 1.469 towards agricultural productivity. Lastly, a 1% increase in GE will lead to an increase of 4.890 of agricultural productivity.

The second long-run cointegrating vector is presented by the equation below:

$$REER=2.708LAX-0.825GCF+0.970LGDP+10.445GE-73.228 \quad (5.3)$$

The results of the second cointegration show that a 1% increase in AX will lead to 2.708 appreciation in real effective exchange rate. GCF has a negative impact on real effective exchange rate by depreciation of -0.825. The 1% increase in GDP will lead to an appreciation of 0.970 towards real effective exchange rate. Lastly a 1% increase in GE will lead to appreciation of 10.445 of real effective exchange rate. However, the second cointegrating vector is not of interest compared to the first cointegrating vector.

Lastly equation 4.6 indicates that a 1% increase in GDP will lead to 0.386 increase in agricultural productivity. Moreover a 1% increase in GE will lead to 3.364 increase in agricultural productivity in the long-run. An increase of 1% in M2 indicates an increase in 0.835 in agricultural productivity. However, 1% increase in REER depreciates agricultural productivity by approximately -0.004 despite that it resulted to be statistically significant. The model reflects that CPI has a negative long-run relationship with agricultural productivity. Consequently, the results suggest that a 1% increase in CPI decreases agricultural productivity by -1.452. The CPI indicates that it is statistically significant along GDP, GE and M2.

Table 5.11 Short run parameters results

ORDER	Equation 4.4	Equation 4.5	Equation 4.6
	Coefficient	***Coefficient***	***Coefficient***
ECT_{-1}	-0.466 (-3.504)*	-0.883 (-4.455)*	-0.243 (-2.508)*
VARIABLES			
D(LGDP)	5.714 (4.022)*	6.101 (3.516)*	3.045 (4.654)*
D(GE)	-0.081 (-0.095)	0.069 (0.563)	0.058 (1.109)
D(GCF)	0.373 (2.256)*	-0.216 (-0.818)	-
D(RINT)	0.790 (0.096)	-	-
D(LM2)	-	-	0.167 (0.262)
D(LREER)	-	58.043 (2.525)*	17.761 (1.288)
D(CPI)	-	-	-0.026 (-0.407)
D(LAX)	-	-0.113 (-0.240)	-

Notes: Values in brackets are t-statistics
* Statistically significant at 1% level
** Statistically significant at 5% level
*** Statistically significant at 10% level

The ECM in table 5.11 was employed to capture the short-run dynamics in agricultural productivity equation and to find out the speed of adjustment. The results for equation 4.4 reflect the speed adjustment is approximately 46.6%. This implies that if there is any deviation from equilibrium only 46.6% of agricultural productivity is corrected in a single year as the variable moves towards restoring equilibrium. Thus, the GDP and GCF have significant impact upon agricultural productivity in the short run since their t-values are greater than 2. GE and RINT are not significant towards agricultural productivity in the short-run since their t-values are less than 2.

Equation 4.5 reflects that the speed of adjustment is 88.3% whereby only that percentage can be corrected in one year. The ECT is also statistically significant at 1% level. Furthermore equation 4.5 imposed restrictions also in the short run since there was existence of two cointegrating vectors. Therefore, the exogeneity test results are presented in the table below which shows speed adjustment in long run equilibrium.

Table 5.12 Exogeneity test for Equation 4.5

	Cointegrating equation 1	Cointegrating equation 2
ECT_{-1}	-0.030 -2.652	0.032 2.996
D(LREER)	6.731 5.196	0.000 (NA)
D(AX)	0.017 0.658	0.000 (NA)
D(GCF)	-0.021 -3.382	-9.000 0.007
D(LGDP)	-0.492 -4.849	0.585 -6.019
?D(GE)	0.003 0.474	-0.001 -0.270
LR test for binding restrictions (rank=2): X^2 = 0.474 Probability = 0.490		

In Table 5.12 the exogeneity shows LR of 0.474 and probability of 0.490 which indicate that the equations are well specified. The error correction term of first cointegrating equation is negative with coefficient of -0.030 and t-statistics of -2.652 which is statistically significant. This implies that 3.0% of gap between agricultural productivity and equilibrium is eliminated every year. In the second cointegrating equation the error correction term in 0.032 and its t-statistics is 2.996 implying that 3.2% is adjusted in one year. The restrictions are imposed on real effective exchange rate and agricultural exports in cointegrating equation 5.2. This indicates that the study of agricultural productivity can function without those two variables.

The coefficient of error term in equation 4.6 is found to be negative but statistically significant at 1% level. Approximately 24.3% of long-run disequilibrium is adjusted from lagged period error shock. In addition, among other variables GDP proves to have a significant impact on agricultural productivity in the short-run while other variables are not statistically significant according to their t-values and do not have any significant impact on agricultural productivity in the short run.

5.6. Diagnostic tests

This section covers the residuals diagnostic testing for all equations. The tests that are conducted include normality test, heteroskedasticity and stability test. The diagnostic checks are performed to the agricultural productivity modeling to validate the evaluation of parameter outcomes achieved by the three models. If any problems from the residuals exist, then it will make the model inefficiency and its parameter estimated to be biased. Below are the three equations indicating the outcomes of the diagnostics checks.

Table 5.13 Diagnostic tests for Equation 4.4

Tests	**Ho**	**T-Statistics**	**Probability**	**Conclusion**
Jarque-Bera	Residuals are normally distributed	47.897	0.000	Reject H_O, therefore residuals are not normally distributed
White (CH-sq)	No heteroskesdasticity	351.272	0.201	Cannot reject H_O, and conclude that there no heteroskedasticity
Reject H_0: if $P < 0.05$				

Figure 5.3 Stability test for Equation 4.4

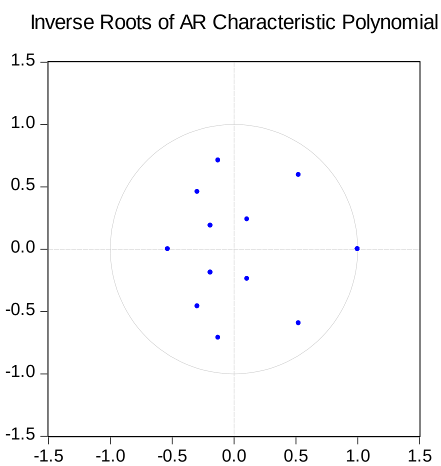


Table 5.14 Diagnostic tests for Equation 4.5

Tests	**Ho**	**T-Statistics**	**Probability**	**Conclusion**
Jarque-Bera	Residuals are normally distributed	20.083	0.065	Reject Ho, therefore residuals are not normally distributed
White (CH-sq)	No heteroskesdasticity	345.824	0.344	Cannot reject H_O, and conclude that there is no heteroskedasticity
Reject H_0: if $P < 0.05$				

Figure 5.4 Stability test for Equation 4.5

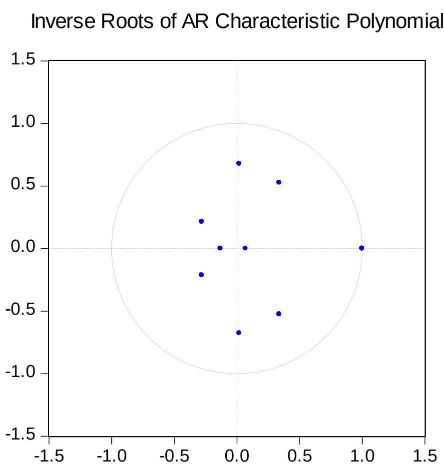
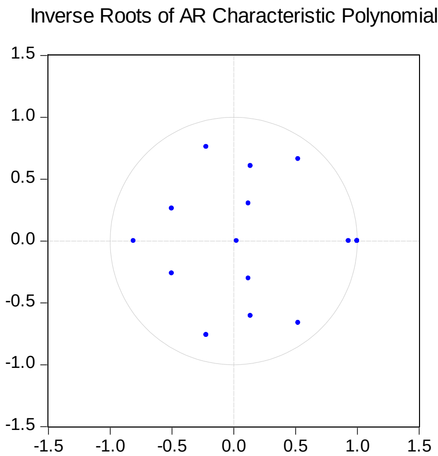


Table 5.15 Diagnostic tests for Equation 4.6

Tests	**Ho**	**T-Statistics**	**Probability**	**Conclusion**
Jarque-Bera	Residuals are normally distributed	20.070	0.065	Reject Ho, therefore residuals are not normally distributed
White (CH-sq)	No heteroskesdasticity	534.807	0.625	Cannot reject Ho, therefore conclude that there is no heterokedasticity
Reject H_0: if $P < 0.05$				

Figure 5.5 Stability test for Equation 4.6



The diagnostic tests presented above covers the normality, heteroskedasticity and stability tests. The normality of the residuals was tested, in equation 4.4 the null hypothesis was rejected concluding that residuals are not normally distributed. Then equation 4.5 and equation 4.6, the test indicated that the residuals were normally distributed. In the case of heteroskedasticity, all models cannot reject the null hypothesis of heteroskedasticity. Therefore, it is concluded that all three models do not suffer from heteroskedasticity problem. Lastly, the stability of estimated VAR equations from AR roots test is shown to stable if all the roots have modulus smaller than one. Regarding the three VAR equations of this study, all the roots lie inside the unit circle. It can be concluded that the VAR satisfy the stability condition.

5.7. Granger causality

As cointegration exists between agricultural productivity and selected macroeconomic variables, the other step to be followed is to test causality employing a granger causality test. This test gives direction of casual association among the variables and it establishes directional causality between the two variables. Table 5.16, 5.17 and 5.18 gives an indication of causality results among the variables from equation 4.4 to equation 4.6.

Table 5.16 Granger causality results for Equation 4.4

Null hypothesis	Obs	Chi-Sq	Prob
Dlog_GDP does not granger cause Dlog_AGRI	37	5.374	0.068
Dlog_AGRI does not granger cause Dlog_GDP	37	7.734	0.021**
Dlog_GCF does not granger cause Dlog_AGRI	37	5.055	0.082
Dlog_AGRI does not granger cause Dlog_GCF	37	2.091	0.352
Dlog_GE does not granger cause Dlog_AGRI	37	13.323	0.001**
Dlog_AGRI does not granger cause Dlog_GE	37	0.539	0.764
Dlog_RINT does not granger cause Dlog_AGRI	37	5.048	0.080
Dlog_AGRI does not granger cause Dlog_RINT	37	0.615	0.735

Notes: Granger cause if P < 0.05

* Statistically significant at 1% level
** Statistically significant at 5% level
*** Statistically significant at 10% level

Table 5.17 Granger causality results for Equation 4.5

Null hypothesis	Obs	Chi-Sq	Prob
Dlog_REER does not granger cause Dlog_AGRI	39	0.119	0.730
Dlog_AGRI does not granger cause Dlog _REER	39	0.647	0.421
Dlog_AX does not granger cause Dlog _AGRI	39	2.901	0.089
Dlog_AGRI does not granger cause Dlog_AX	39	0.899	0.343
Dlog_GCF does not granger cause Dlog _AGRI	39	0.177	0.674
Dlog_AGRI does not granger cause Dlog _GCF	39	1.070	0.301
Dlog_GDP does not granger cause Dlog _AGRI	39	0.116	0.733
Dlog_AGRI does not granger cause Dlog _GDP	39	1.070	0.301
Dlog_GE does not granger cause Dlog _AGRI	39	4.289	0.038**
Dlog_REER does not granger cause Dlog _GE	39	0.096	0.757

Notes: Granger cause if P < 0.05

* Statistically significant at 1% level
** Statistically significant at 5% level
*** Statistically significant at 10% level

Table 5.18 Granger causality results for Equation 4.6

Null hypothesis	Obs	Chi-Sq	Prob
Dlog_CPI does not granger cause Dlog_AGRI	39	7.138	0.028**
Dlog_AGRI does not granger cause Dlog_CPI	39	0.006	0.998
Dlog_GDP does not granger cause Dlog_AGRI	39	9.755	0.008**
Dlog_AGRI does not granger cause Dlog_GDP	39	5.703	0.058
Dlog_GE does not granger cause Dlog_AGRI	39	18.103	0.000**
Dlog_AGRI does not granger cause Dlog_GE	39	1.118	0.572
Dlog_M2 does not granger cause Dlog_AGRI	39	1.398	0.497
Dlog_AGRI does not granger cause Dlog_M2	39	5.663	0.059
Dlog_REER does not granger cause Dlog_AGRI	39	2.078	0.354
Dlog_AGRI does not granger cause Dlog_REER	39	1.961	0.375

Notes: Granger cause if P < 0.05

* Statistically significant at 1% level
** Statistically significant at 5% level
*** Statistically significant at 10% level

The results from granger causality test are statistically significant at 5% level in all equations. Equation 4.4 shows that agricultural productivity granger cause gross domestic product with probability of 0.021. It indicates that the higher agricultural productivity the more impact it will have on South African economy and increase its share to gross domestic product. Government expenditure reveals that it granger cause agricultural productivity by probability of 0.001, the hypothesis of government expenditure does not granger cause agricultural productivity is rejected at 5% level of significance.

Equation 4.5 shows that government expenditure granger cause agricultural productivity with probability of 0.038. This indicates how important is government expenditure towards agricultural sector and the improvement of South Africa's food security. The rest of the variables show no evidence of granger causality among each other as their probabilities are greater than 0.05% level of significance.

In equation 4.6, consumer price index with probability of 0.028, gross domestic product with probability of 0.008 and government expenditure with probability of 0.000 granger cause agricultural productivity. While the rest of the variables does not show any support of causality relationship among agricultural productivity.

In all three equations the results shows that government expenditure is always granger causing agricultural productivity. It indicates that it is the most influential macroeconomic variable towards agricultural productivity. This variable is followed by gross domestic product in equation 4.4 and equation 4.6 whereby in equation 4.4 agricultural productivity granger cause gross domestic product and equation 4.6 is verse versa were gross domestic product granger cause agricultural productivity. Overall, granger causality test results indicate that there is significant impact of macroeconomics variables towards agricultural productivity and verse versa.

5.8. Impulse response

To demonstrate the unitary shock on macroeconomic variables selected, the variables are shocked in each equation. The impulse response focuses on tracing the effect of a one-time shock to one of innovations of current and future values of independent variables. In addition, it is used to investigate the transmission occurrence from one variable to another. The results of each shocked equations are presented below.

Figure 5.6 Impulse responses for Equation 4.4

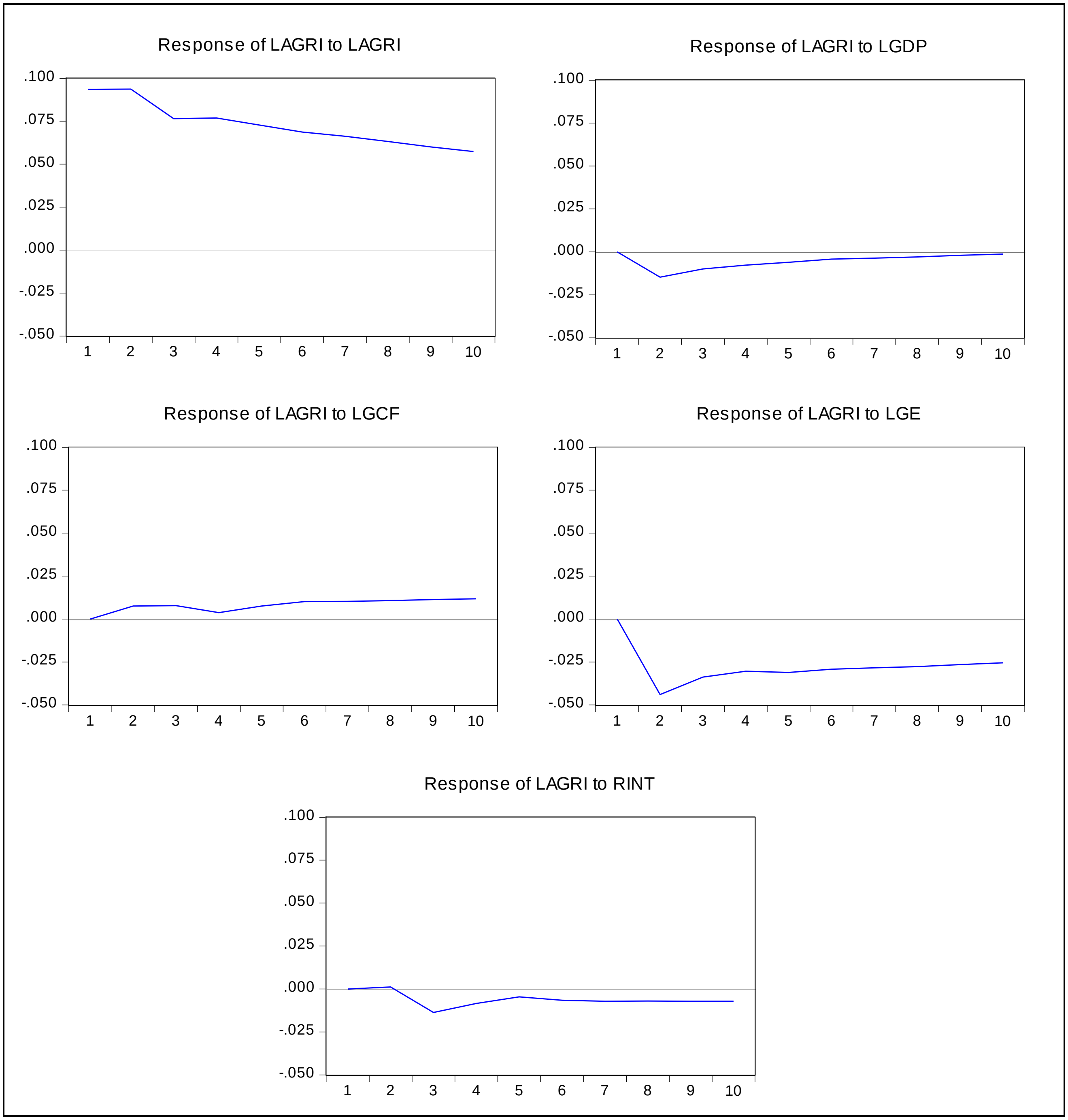


Figure 5.7 Impulse responses for Equation 4.5

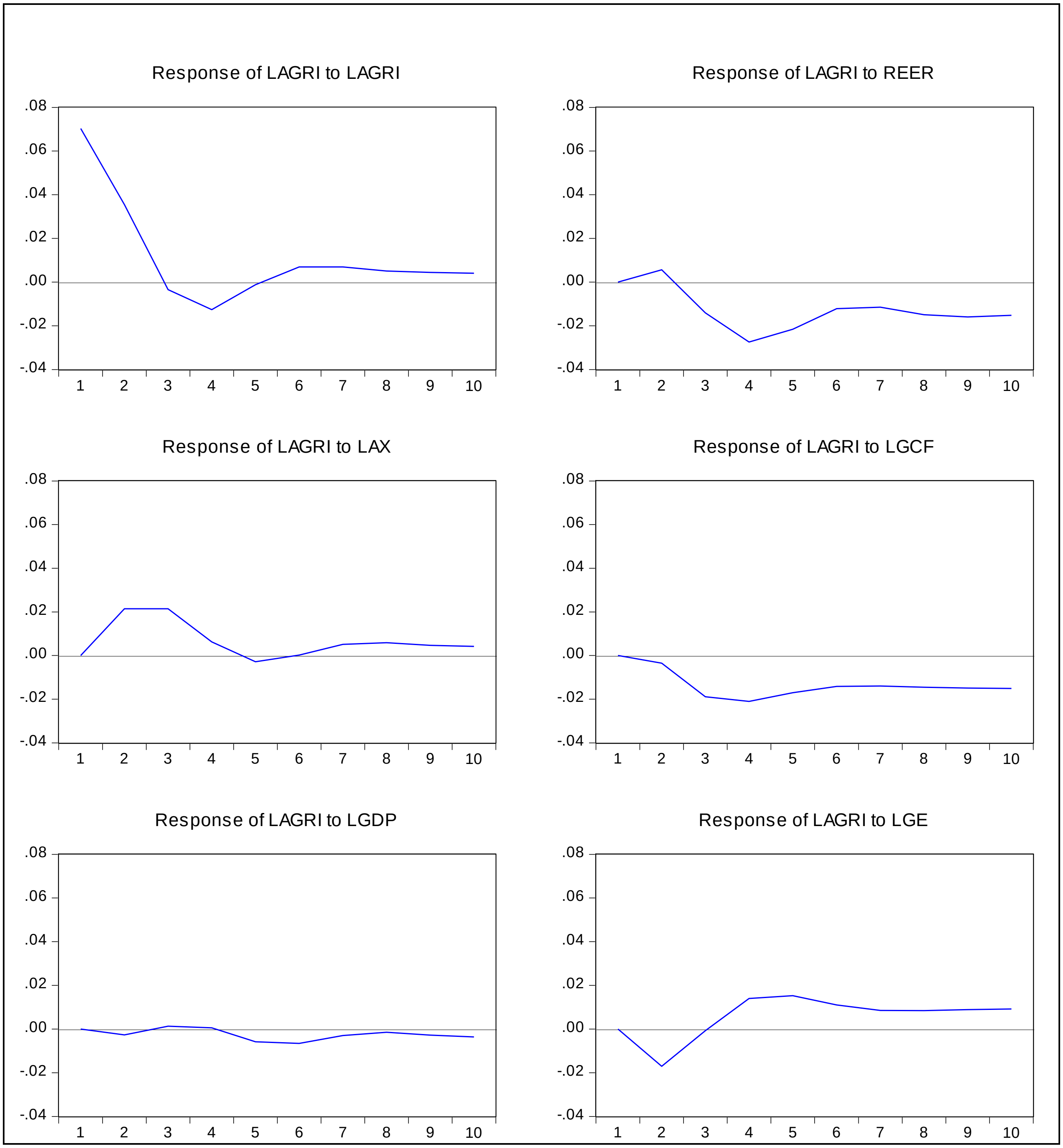
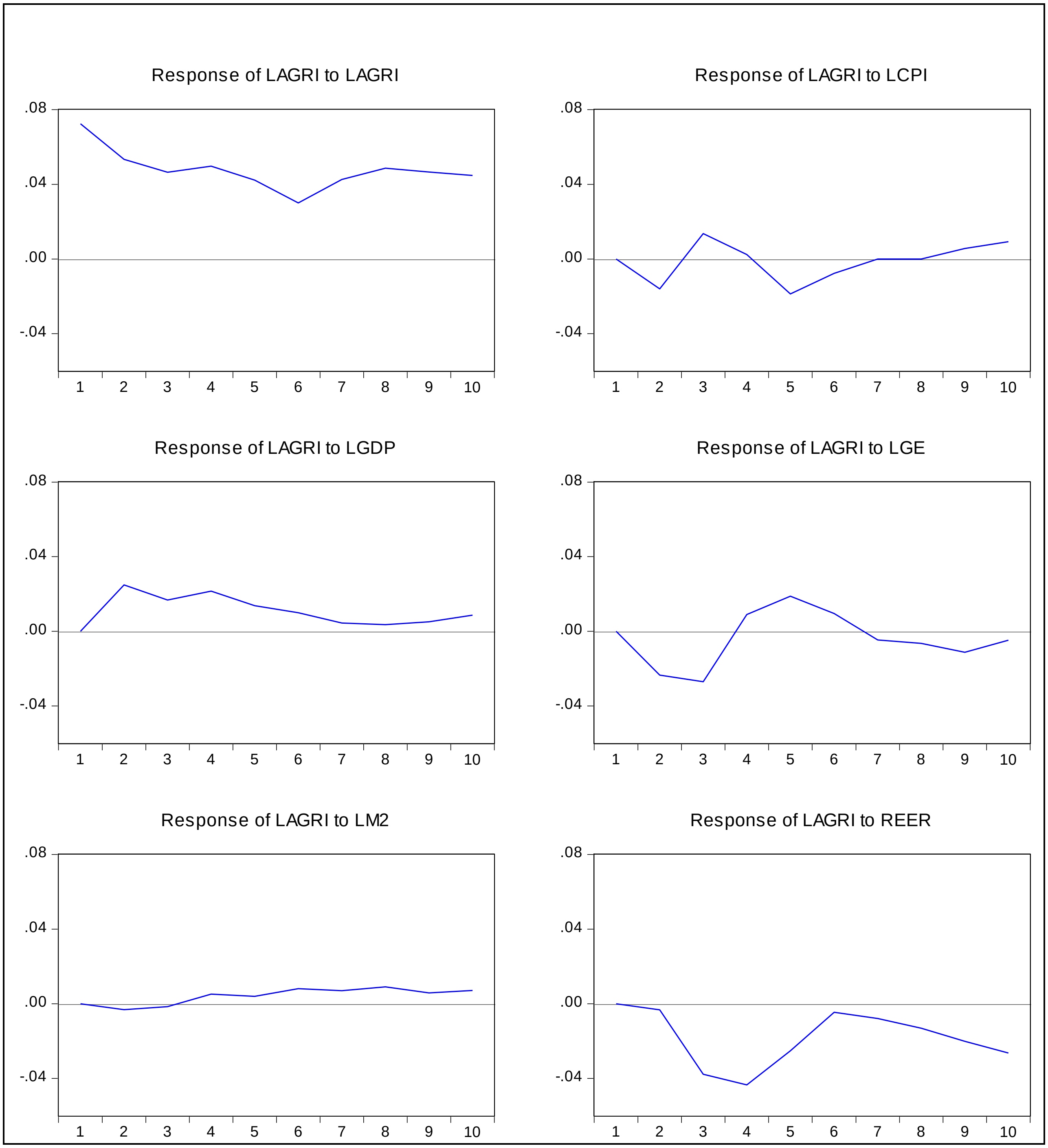


Figure 5.8 Impulse responses for Equation 4.6



In all the equations the direction agricultural productivity response to innovations in the systems is shown to be theoretically and reasonable in most cases. Impulse response of equation 4.4 shows that agricultural productivity responds positively to shocks itself with a downward trend. However agricultural productivity shock to GDP is negative both in the short and long run periods. The impulse response results validate other results reported earlier in the study and agrees with economic thought of agricultural sector in South Africa has limited impact towards the country's GDP. In the case of AGRI shock to GCF there is a positive shock in all periods, this indicate a stable relationship among the two variables both in the short and long run. AGRI shock to GE and RINT indicate a negative shock both in the short and long run. The response of RINT was close to zero however in period 1 and 2 the response was equal to zero.

Figure 5.7 of equation 4.5, AGRI response to shock itself fluctuated from being positive in period 1 to 3 and started a downward slope in the middle of the third period. In the fifth period it improved and showed a positive response onwards. AGRI response to REER started off showing a positive shock for the first two periods, however afterwards it responded negatively to shock for the whole periods. Thus, it is similar to GCF and GDP those two showed a negative shock in all periods for long and short run.

Although GDP was slightly close to zero and an inch above it in the middle of the period afterwards it continued to downfall. AGRI shock to AX started off with positive response up until period 4, where it started to respond negatively in period 5 and 6, afterwards it continued to pick up consistently in the long run. This proves that in the long run AX has a positive impact on AGRI and if it continues like that it will have a positive impact on South African economy. Lastly, GE response to its shock from AGRI shows a slight negative impact on AGRI for the first two periods however from period 3 onwards its response was positive. This indicates that GE towards agricultural sector in the country will have a positive impact in the long run and it might end up improving the stability of the agricultural sector in the country.

According to equation 4.6, AGRI responds positively to its shock similar to the shock in equation 4. GDP also responded positively to the shock from AGRI indicating that in this equation agriculture tend to contribute positively to South African GDP. The response of M2 also indicates a positive impact towards AGRI in the long run although it started off with a negative response for the first two periods. AGRI shock to CPI and GE fluctuate from negative to positive and repeatedly. This indicates that in the short and long run there is no stable relationship among agricultural productivity and two macroeconomic variables (CPI and GE). Equation 4.4, GE was consistently responding negatively in all periods but in equation 4.5 it responded negatively for the first two periods and from the third period it consistently responds positively to AGRI shock. Thus, REER response to AGRI shock showed a negative response suggesting that the shock may cause REER to appreciate causing a strain on agricultural productivity and the economy.

5.9. Summary

Econometric results of this study were presented in this chapter and six sections were established. Whereby section one of unit root testing presented the informal and formal tests of stationarity. In terms of formal testing ADF and PP test were employed and both methods revealed non-stationarity of the data at levels. After the first difference the data become stationary and the series was integrated of the same order I (1).

The second section of the study tested cointegration using the Johansen cointegration approach. The study compared three different equations presented in methodology chapter 4 using different variable within the selected macroeconomic variables. Each equation presented different results giving the study an advantage to explore how various set of macroeconomic variables impact agricultural productivity. The trace and maximum eigenvalue cointegration test were utilised. The results for equation 4.4 showed one cointegrating vector for trace and maximum eigen value test while equation 4.5 indicated 2 cointegrating vectors for each test further restrictions were imposed. Lastly, equation 4.6 showed 1 cointegrating vector in trace test and 2 cointegrating vector in maximum eigenvalue test. In addition, all three equations showed that there is long-run equilibrium relationship among variables. A maximum lag of 2 was used to permit adjustments of the equations.

The third section presented the VECM equations since variables can either have a long-run or short-run impact. In the long-run not all variables have positive impact and are proven to be statistically significant in all three equations. In equation 4.4 all variables have a positive long-run impact on agricultural productivity, but they are not statistically significant. Equation 4.5 results indicate that only GE and AX has a positive impact towards agricultural productivity. GDP and GCF has a negative impact on agricultural productivity. The last equation 4.6 showed GDP and GCF are the only variables that have positive impact on agricultural productivity but GE, REER and CPI have a negative impact on agricultural productivity. The VECM for all equations was estimated.

The fourth section presented diagnostic tests that were carried out by the study. Normality test was performed and in equation 4.4, residuals were not normally distributed, but in equation 4.5 and equation 4.6 residuals were normally distributed. The next test was white heteroskedasticity and all equations indicate no heteroskedasticity. The stability test using AR roots test was employed and all VAR equations of the three equations were stable. The last 2 sections of granger causality and impulse response function were employed to examine whether macroeconomic variables have any impact on agricultural productivity or vice versa. The results suggest that there is significant evidence of causality on macroeconomic variables towards agricultural productivity or vice versa.

Overall, the decision to implement and analyse three variations of equations was to see how different set of macroeconomic variables impact agricultural productivity. Regarding the existing empirical literature relating to the study at hand, there has been no study that implemented various equations in their analysis. Therefore this study will add value to empirical literature. This study will furthermore be a guide that when doing empirical analysis the study can go an extra mile to see how different set of variables react towards certain analysis. By using set of different equations it also helps on how to conclude which variables are important during the analysis.

Among the three implemented equations, the most preferred is equation 4.4. Reason being: In cointegration test, the equation reacted well by showing at least one cointegrating vector in both tests indicating that there is long run relation among the variables. Long run parameters under VECM also indicated a positive long run relationship between macroeconomic variables and agricultural productivity. The error correction term was satisfactory. Under impulse response agricultural productivity shock to GDP resulted to being negative both in the short and long run.

These results validate the economic theory of agricultural sector in South Africa that it has limited contribution to the country's GDP as in 2018 the sector contributed approximately 2.5%. In addition a negative shock to RINT by agricultural productivity shows that the agricultural sector does not react well to higher interest rates. Increased interest rates will make the borrowing from the bank and cost of production to be more costly. Thus this will result to farmers having low earnings. This equation also answered the questions that were imposed in chapter one satisfactory supported by the results obtained.

Therefore after all the analysis, reliable results and policy recommendations are derived from this study. As estimation, presentations and analysis are outlined in this chapter; the next chapter which is the concluding chapter presents summary, key findings, policy recommendations and the suggestions for further studies.

CHAPTER 6

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

6.1. Introduction

The purpose of the study was to econometrically analyze the impact of macroeconomic variables towards agricultural productivity in South Africa for the period 1975 to 2016. This chapter attempts to draw summary and conclusions from the results and provide policy recommendations for future policy formulation also suggestions for further research. As a result, this chapter is structures as follows: section 6.2 is the summary of the study, section 6.3 is the key findings of the study. In addition, section 6.4 is policy recommendations and suggestions for further research.

6.2. Summary

The first chapter of this study outlined the introduction and background of the study. It laid all the ground work necessary to the study including the problem statement, objectives, research questions, research hypotheses, research method along with justification of the study and lastly the organization of the study. Chapter two gave the structure of agricultural sector. Following the structure of agricultural sector was chapter three which analyzed the theoretical and empirical literature applicable to this study. Methodology was discussed in chapter four whereby the study applied the Johansen procedure with agricultural productivity as the dependent variable and agricultural exports, real effective exchange rate, gross domestic product, gross capital formation, government expenditure, real interest rate, consumer price index and money supply as independent variables. Then chapter five covered the results and discussions of the study.

6.3. Key findings

As the study analyzed the impact of macroeconomic variables in South Africa, three equations were derived from the variables and it resulted to the study having different conclusions. The long-run models of the study show that in equation 4.4. GDP, GE, GCF and RINT indicate a positive relationship with agricultural productivity in the long-run. Moreover, in equation 4.5

GDP and GCF have a negative relation with agricultural productivity, whilst GE and AX have a positive impact on productivity of agriculture. In addition, equation 4.5 imposed restrictions on REER and AGRI. The restrictions imposed indicate that REER does not really play an important part in determining the productivity of agriculture. The last equation of 4.6 shows that GDP, GE M2 have a long-run relationship with agricultural productivity, while REER and CPI have a negative relation with agricultural productivity in the long-run. In summary the study showed that there is long-run relation in all the three equations and among different variables used for each equation.

The short-run model was estimated for all three equations. For equation 4.4 the estimation revealed a 46.6% convergence towards equilibrium adjusted to be adjusted in the long run compared to equation 4.5 of 88.3% and equation 4.6 by 24.3%. This concludes that equation 4.6 has the lowest speed of adjustment compared to other equations. The diagnostic tests along with stability test were conducted for every model to check the efficiency and stability of the models. In all the equations the residuals are not normally distributed however they do not suffer from heteroskedasticity and all the models are stable.

The study further analyzed the granger causality to check if whether there are casual relations among agricultural productivity and macroeconomic variables in South Africa. In all the equations GE is granger causing agricultural productivity while GDP only granger cause AGRI in equation 4.6 and in equation 4.4 AGRI granger cause GDP. In summary GE is the most influential macroeconomic variable towards agricultural productivity. CPI also granger causes AGRI in equation 4.6. The rest of the variables do not have any casual relation with agricultural productivity. The study concludes that there is significant evidence of causality between agricultural productivity and macroeconomic variables. The results are believed to be efficient and stable and can be used for further references.

6.4. Policy recommendations

The agricultural sector plays a distinctive role on individuals and economy capacity entirely. This is to be as an intermediate to produce other goods or as job creator in rural areas. It is thus, of necessity for policies governing the sector not only be for short term but for long term. The results indicated that government spending and gross capital formation has long run relation with agricultural productivity for that reason it is vital for government to increase their spending on agricultural sector. This will make the sector to be able to acquire advanced tools to increase its productivity, also government should encourage the use of those tools for the sector to maximize their production. Capital formation through investment on labour and land and other agricultural machinery tend to increase productivity as it enables farmers to use resources efficiently. More investment in agricultural sector are vital, this is to urge policy makers to allow investments from both private and public sector to ensure maximum upgrading on the sector.

As expected for the study that real interest rate will have a negative impact on agricultural productivity, the results of the long run cointegration confirms the theory. This indicates that high interest rate slows the rate of investment in the sector, it also lowers the expected profits for farmers and reduces the farmland value. Policy makers should ensure that interest rate is kept lower by reviewing the monetary policy and encouraging farmers to take out fixed rates loans when interest rates are lower.

Long run positive results obtained for agricultural exports impact to agricultural productivity. This makes the government to diversify and promote agricultural exports and fully explore the benefits of the sector. This is to grow and contribute larger to the South African gross domestic product. In terms of long run negative relation of inflation towards agricultural productivity the monetary policy authorities of South Africa should continue to monitor the trend of inflation and ensure that it is kept low preferably at one digit.

6.5. Limitations and suggestions for further studies

This study could not focus on all aspects impacting agricultural productivity in South Africa. For example, it investigated certain key macroeconomic variables only, rather than the environmental factors such as land, climate, soil and water which also have an impact on the productivity of agriculture. Due to lack of efficient and consistent of data available some of the macroeconomic variables were not included in the study, however for future studies, when data becomes available some macroeconomic variables which were left out in the study may be incorporated.

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APPENDIX 1

DATA USED IN THE STUDY

YEARS	AGRI	GDP	GE	GCF	RINT	REER	AX	CPI	M2
1975	7.65	R 1 206 407 000 000.00	12.87	32.34	0.88	157.22	R 124 900 000.00	3.43	R 10 800 000 000.00
1976	6.74	R 1 233 550 000 000.00	13.58	30.38	1.64	144.03	R 1 237 400 000.00	3.80	R 12 006 000 000.00
1977	7.04	R 1 232 390 000 000.00	13.05	29.75	1.20	143.92	R 1 337 500 000.00	4.23	R 13 009 000 000.00
1978	6.72	R 1 269 541 000 000.00	13.81	26.67	0.46	135.37	R 1 543 800 000.00	4.70	R 15 192 000 000.00
1979	5.97	R 1 317 663 000 000.00	13.75	27.38	-4.40	140.64	R 1 692 300 000.00	5.33	R 17 347 000 000.00
1980	6.20	R 1 404 900 000 000.00	12.97	31.36	-12.32	153.76	R 2 881 467 580.00	6.05	R 21 707 000 000.00
1981	6.44	R 1 480 213 000 000.00	13.69	34.12	3.51	161.80	R 2 651 775 348.00	6.98	R 26 889 000 000.00
1982	5.68	R 1 474 538 000 000.00	15.38	26.53	4.69	153.31	R 2 205 305 100.00	8.00	R 31 356 000 000.00
1983	4.41	R 1 447 310 000 000.00	15.08	27.17	0.12	168.74	R 1 892 585 812.00	8.98	R 38 465 000 000.00
1984	4.79	R 1 521 110 000 000.00	16.78	25.54	9.74	148.85	R 1 686 945 574.00	10.02	R 47 825 000 000.00
1985	5.18	R 1 502 682 000 000.00	17.09	22.05	4.01	113.04	R 1 625 000 000.00	11.65	R 54 577 000 000.00
1986	4.96	R 1 502 950 000 000.00	17.52	21.02	-1.73	104.34	R 1 799 000 000.00	16.05	R 56 921 000 000.00
1987	5.58	R 1 534 523 000 000.00	18.30	17.78	0.16	117.77	R 2 071 000 000.00	18.11	R 69 464 000 000.00
1988	5.82	R 1 598 975 000 000.00	17.78	21.23	2.23	111.23	R 1 917 361 566.00	20.77	R 93 941 000 000.00
1989	5.40	R 1 637 267 000 000.00	17.74	22.75	4.78	111.68	R 2 011 254 518.00	23.75	R 119 022 000 000.00
1990	4.62	R 1 632 064 000 000.00	18.56	19.41	4.03	114.82	R 1 690 813 660.00	27.39	R 134 244 000 000.00
1991	4.55	R 1 615 446 000 000.00	18.66	19.02	3.79	119.50	R 1 736 636 596.00	31.19	R 155 363 000 000.00
1992	3.80	R 1 580 923 000 000.00	18.97	16.77	2.81	123.47	R 1 780 073 001.00	34.22	R 172 214 000 000.00
1993	4.17	R 1 600 424 000 000.00	19.64	15.16	5.53	121.17	R 1 650 699 260.00	37.28	R 178 963 000 000.00
1994	4.60	R 1 652 184 000 000.00	19.80	17.72	6.99	115.99	R 2 365 017 742.00	40.52	R 215 823 000 000.00
1995	3.86	R 1 703 660 000 000.00	18.12	19.17	10.77	112.74	R 2 386 949 282.00	43.50	R 245 722 000 000.00
1996	4.21	R 1 777 032 000 000.00	19.15	18.04	11.17	103.78	R 2 504 239 013.00	47.24	R 295 313 000 000.00
1997	4.03	R 1 824 067 000 000.00	19.29	17.72	13.01	109.59	R 2 601 932 308.00	50.49	R 350 700 000 000.00
1998	3.78	R 1 833 504 000 000.00	18.91	17.99	10.21	100.63	R 2 486 686 637.00	53.10	R 393 806 000 000.00
1999	3.56	R 1 876 740 000 000.00	18.58	17.04	5.20	95.21	R 2 475 611 672.00	55.94	R 446 935 000 000.00
2000	3.29	R 1 954 710 000 000.00	18.39	16.37	3.13	92.12	R 3 270 443 038.00	64.54	R 474 848 000 000.00
2001	3.53	R 2 008 181 000 000.00	18.53	15.74	8.66	81.35	R 3 199 614 891.00	68.33	R 544 056 000 000.00
2002	3.71	R 2 081 837 000 000.00	18.81	16.28	4.47	69.49	R 3 328 530 664.00	69.27	R 632 621 000 000.00
2003	3.35	R 2 143 232 000 000.00	19.06	17.11	4.91	90.28	R 4 237 762 076.00	71.63	R 733 453 000 000.00
2004	3.06	R 2 240 847 000 000.00	19.16	18.47	4.62	97.62	R 4 661 272 060.00	74.95	R 818 740 000 000.00
2005	2.67	R 2 359 099 000 000.00	19.48	18.31	3.97	98.89	R 5 246 023 152.00	80.27	R 963 515 000 000.00
2006	2.61	R 2 491 295 000 000.00	18.15	20.18	5.78	94.94	R 4 954 964 080.00	89.53	R 1 156 842 000 000.00
2007	2.96	R 2 624 840 000 000.00	17.81	20.99	3.91	89.26	R 5 573 691 586.00	95.92	R 1 396 325 000 000.00
2008	3.17	R 2 708 600 000 000.00	18.66	23.15	3.27	79.43	R 7 036 562 552.00	100.00	R 1 561 612 000 000.00
2009	2.99	R 2 666 939 000 000.00	19.86	20.70	2.32	86.58	R 6 678 820 196.00	105.00	R 1 588 265 000 000.00
2010	2.63	R 2 748 008 000 000.00	20.23	19.51	3.29	100.00	R 9 931 543 382.00	110.94	R 1 677 329 000 000.00
2011	2.54	R 2 838 257 118 400.00	19.86	19.72	2.22	97.92	R 11 101 706 275.00	117.32	R 1 797 771 000 000.00
2012	2.41	R 2 901 077 786 000.00	20.26	19.97	3.17	92.60	R 10 498 624 928.00	124.44	R 1 867 804 000 000.00
2013	2.33	R 2 973 174 960 200.00	20.57	21.26	4.21	82.84	R 11 137 231 593.00	130.14	R 1 897 659 000 000.00
2014	2.43	R 3 028 089 752 700.00	20.71	20.84	3.43	77.60	R 11 373 565 496.00	138.38	R 1 916 765 000 000.00
2015	2.32	R 3 066 835 319 500.00	20.46	20.71	4.09	77.16	R 9 573 255 915.00	130.30	R 1 946 572 000 000.00
2016	2.44	R 3 084 174 069 800.00	20.47	19.42	3.45	71.53	R 9 964 642 751.00	138.90	R 1 976 889 000 000.00

APPENDIX 2

JOHANSEN COINTEGRATION

EQUATION 4.4

Date: 10/29/18 Time: 09:59
Sample (adjusted): 1978 2014
Included observations: 37 after adjustments
Trend assumption: Linear deterministic trend (restricted)
Series: LAGRI LGDP LGCF LGE RINT
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.646903	93.44490	88.80380	0.0222
At most 1	0.390497	54.92748	63.87610	0.2244
At most 2	0.360951	36.60835	42.91525	0.1850
At most 3	0.268230	20.04072	25.87211	0.2239
At most 4	0.204951	8.486012	12.51798	0.2145

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.646903	38.51742	38.33101	0.0476
At most 1	0.390497	18.31914	32.11832	0.7786
At most 2	0.360951	16.56763	25.82321	0.4947
At most 3	0.268230	11.55471	19.38704	0.4577
At most 4	0.204951	8.486012	12.51798	0.2145

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

EQUATION 4.5

Date: 10/28/18 Time: 21:52
Sample (adjusted): 1977 2015
Included observations: 39 after adjustments
Trend assumption: Linear deterministic trend (restricted)
Series: LAGRI REER LAX LGCF LGDP LGE
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.683789	137.7356	117.7082	0.0015
At most 1 *	0.643992	92.83308	88.80380	0.0248
At most 2	0.440415	52.55381	63.87610	0.3077
At most 3	0.309077	29.91198	42.91525	0.5074
At most 4	0.204810	15.49264	25.87211	0.5338
At most 5	0.154708	6.554862	12.51798	0.3933

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.683789	44.90250	44.49720	0.0451
At most 1 *	0.643992	40.27927	38.33101	0.0295
At most 2	0.440415	22.64184	32.11832	0.4445
At most 3	0.309077	14.41934	25.82321	0.6861
At most 4	0.204810	8.937775	19.38704	0.7308
At most 5	0.154708	6.554862	12.51798	0.3933

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

RESTRICTIONS IMPOSED ON EQUATION 4.5

Vector Error Correction Estimates
Date: 10/28/18 Time: 22:15
Sample (adjusted): 1977 2015
Included observations: 39 after adjustments
Standard errors in () & t-statistics in [ ]

Cointegration Restrictions:
A(2,2)=0, A(3,2)=0
Convergence achieved after 31 iterations.
Not all cointegrating vectors are identified
LR test for binding restrictions (rank = 2):

Chi-square (1)	0.474791
Probability	0.490792

Cointegrating Eq:	CointEq1	CointEq2
LAGRI(-1)	8.926932	-17.36397
REER(-1)	-0.055141	-0.065083
LAX(-1)	0.649528	2.708736
LGCF(-1)	3.065308	-0.825655
LGDP(-1)	1.469504	0.970217
LGE(-1)	4.890157	10.44529
@TREND(75)	0.037595	-0.875974
C	-99.87319	-73.22837

Error Correction:	D(LAGRI)	D(REER)	D(LAX)	D(LGCF)	D(LGDP)	D(LGE)
CointEq1	-0.030841	6.731734	0.017678	-0.021055	-0.492051	0.003399
	(0.01163)	(1.29535)	(0.02685)	(0.01523)	(0.10147)	(0.00716)
	[-2.65298]	[5.19683]	[0.65829]	[-1.38233]	[-4.84932]	[0.47465]
CointEq2	0.032110	0.000000	0.000000	-9.00E-05	-0.585664	-0.001732
	(0.01072)	(0.00000)	(0.00000)	(0.01238)	(0.09730)	(0.00641)
	[2.99602]	[NA]	[NA]	[-0.00727]	[-6.01926]	[-0.27000]

EQUATION 4.6

Date: 10/28/18 Time: 21:46
Sample (adjusted): 1978 2016
Included observations: 39 after adjustments
Trend assumption: Linear deterministic trend (restricted)
Series: LAGRI LCPI LGDP LGE LM2 REER
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.831966	161.4279	117.7082	0.0000
At most 1 *	0.577515	91.86802	88.80380	0.0295
At most 2	0.523195	58.26558	63.87610	0.1355
At most 3	0.307365	29.38032	42.91525	0.5391
At most 4	0.234460	15.05750	25.87211	0.5698
At most 5	0.112118	4.637735	12.51798	0.6489

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.831966	69.55985	44.49720	0.0000
At most 1	0.577515	33.60244	38.33101	0.1582
At most 2	0.523195	28.88526	32.11832	0.1181
At most 3	0.307365	14.32282	25.82321	0.6946
At most 4	0.234460	10.41977	19.38704	0.5741
At most 5	0.112118	4.637735	12.51798	0.6489

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

APPENDIX 3

VECTOR ERROR CORRECTION MODEL

EQUATION 4.4

Vector Error Correction Estimates
Date: 10/29/18 Time: 10:02
Sample (adjusted): 1978 2014
Included observations: 37 after adjustments
Standard errors in () & t-statistics in [ ]

Cointegrating Eq:	CointEq1				
LAGRI(-1)	1.000000				
LGDP(-1)	0.084551 (0.03743) [-2.25881]				
LGCF(-1)	0.475057 (0.18120) [-2.62179]				
LGE(-1)	1.212444 (0.36444) [-3.32689]				
RINT(-1)	0.004858 (0.00563) [-0.86289]				
@TREND(75)	0.038469 (0.00339) [11.3521]				
C	5.922894				
Error Correction:	D(LAGRI)	D(LGDP)	D(LGCF)	D(LGE)	D(RINT)
CointEq1	-0.466219 (0.13305) [-3.50405]	5.714634 (1.42070) [4.02242]	0.373852 (0.16570) [2.25626]	-0.081921 (0.08589) [-0.95381]	0.790033 (8.15968) [0.09682]

EQUATION 4.5

Vector Error Correction Estimates
Date: 10/28/18 Time: 22:11
Sample (adjusted): 1977 2015
Included observations: 39 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	CointEq2
LAGRI(-1)	1.000000	0.000000
REER(-1)	0.000000	1.000000
LAX(-1)	0.055405	21.15164
	(0.06016)	(10.3867)
	[-0.92102]	[-2.03641]
LGCF(-1)	- 0.147751	31.25662
	(0.13099)	(22.6163)
	[1.12799]	[-1.38204]
LGDP(-1)	-0.029804	21.89477
	(0.01926)	(3.32586)
	[1.54726]	[-6.58318]
LGE(-1)	0.134577	111.2410
	(0.21919)	(37.8466)
	[-0.61396]	[2.93926]
@TREND(75)	0.031733	-4.490128
	(0.00475)	(0.82065)
	[6.67660]	[5.47144]
C	-2.034529	1493.501

Error Correction:	D(LAGRI)	D(REER)	D(LAX)	D(LGCF)	D(LGDP)	D(LGE)
CointEq1	-0.883383	58.04305	-0.113674	-0.216337	6.101067	0.069682
	(0.19828)	(22.9828)	(0.47322)	(0.26421)	(1.73481)	(0.12366)
	[-4.45529]	[2.52550]	[-0.24021]	[-0.81881]	[3.51685]	[0.56350]
CointEq2	-0.000669	-0.381930	-0.002399	0.001001	0.067242	-2.24E-05
	(0.00110)	(0.12718)	(0.00262)	(0.00146)	(0.00960)	(0.00068)
	[-0.60947]	[-3.00318]	[-0.91602]	[0.68486]	[7.00470]	[-0.03267]

EQUATION 4.6

Vector Error Correction Estimates
Date: 10/28/18 Time: 22:02
Sample (adjusted): 1978 2016
Included observations: 39 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1					
LAGRI(-1)	1.000000					
LCPI(-1)	1.452463 (0.24697) [5.88119]					
LGDP(-1)	0.386661 (0.04835) [-7.99670]					
LGE(-1)	3.364467 (0.50990) [-6.59833]					
LM2(-1)	0.835005 (0.20031) [-4.16859]					
REER(-1)	-0.004618 (0.00165) [2.79899]					
@TREND(75)	0.059013 (0.01518) [3.88793]					
C	37.81437					
Error Correction:	D(LAGRI)	D(LCPI)	D(LGDP)	D(LGE)	D(LM2)	D(REER)
CointEq1	-0.243391 (0.09701) [-2.50894]	-0.026838 (0.06584) [-0.40760]	3.045577 (0.65427) [4.65489]	0.058979 (0.05317) [1.10930]	0.167778 (0.06395) [2.62351]	17.76158 (13.7873) [1.28826]

APPENDIX 4

DIAGNOSTIC TESTS

EQUATION 4.4

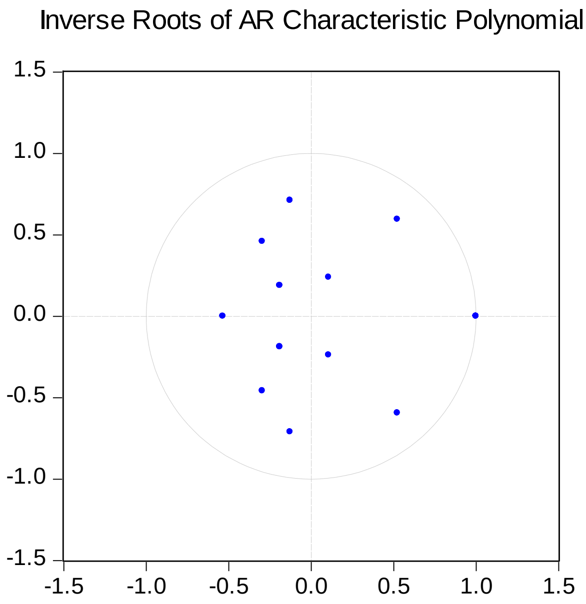
VEC Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 10/16/18 Time: 13:26
Sample: 1975 2016
Included observations: 37

Component	Jarque-Bera	df	Prob.
1	14.15658	2	0.0008
2	31.30106	2	0.0000
3	0.695275	2	0.7064
4	1.577096	2	0.4545
5	0.167874	2	0.9195
Joint	47.89789	10	0.0000

VEC Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Date: 10/16/18 Time: 13:28
Sample: 1975 2016
Included observations: 37

Joint test:

Chi-sq	Df	Prob.
351.2723	330	0.2014


Inverse Roots of AR Characteristic Polynomial
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5

EQUATION 4.5

VEC Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 10/29/18 Time: 10:13
Sample: 1975 2016
Included observations: 39

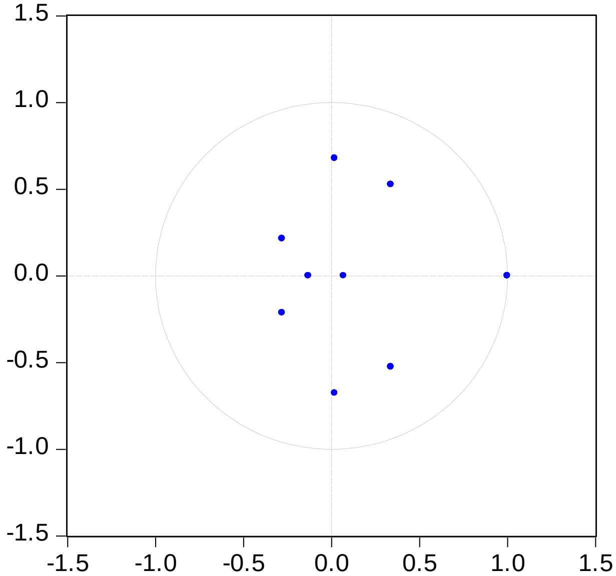
Component	Jarque-Bera	df	Prob.
1	4.210596	2	0.1218
2	0.141847	2	0.9315
3	2.572369	2	0.2763
4	2.733194	2	0.2550
5	9.238354	2	0.0099
6	1.187456	2	0.5523
Joint	20.08382	12	0.0655

VEC Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Date: 10/29/18 Time: 10:14
Sample: 1975 2016
Included observations: 39

Joint test:

Chi-sq	Df	Prob.
345.8244	336	0.3442

Inverse Roots of AR Characteristic Polynomial



EQUATION 4.6

VEC Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 10/16/18 Time: 12:34
Sample: 1975 2016
Included observations: 39

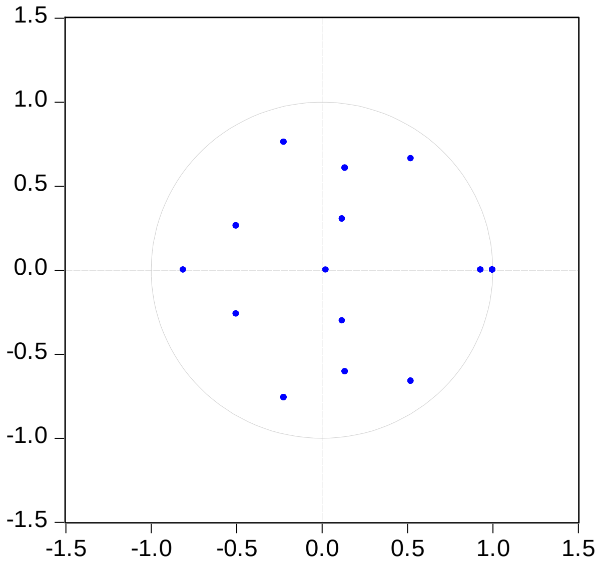
Component	Jarque-Bera	df	Prob.
1	13.29257	2	0.0013
2	0.319781	2	0.8522
3	0.299679	2	0.8608
4	4.349745	2	0.1136
5	0.944648	2	0.6236
6	0.863662	2	0.6493
Joint	20.07008	12	0.0658

VEC Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Date: 10/16/18 Time: 12:31
Sample: 1975 2016
Included observations: 39

Joint test:

Chi-sq	Df	Prob.
534.8077	546	0.6258

Inverse Roots of AR Characteristic Polynomial



APPENDIX 5

GRANGER CAUSALITY

EQUATION 4.4

VEC Granger Causality/Block Exogeneity Wald Tests
Date: 10/29/18 Time: 10:23
Sample: 1975 2016
Included observations: 37

Dependent variable: D(LAGRI)

Excluded	Chi-sq	df	Prob.
D(LGDP)	5.373952	2	0.0681
D(LGCF)	5.005231	2	0.0819
D(LGE)	13.32347	2	0.0013
D(RINT)	5.047527	2	0.0802
All	32.43915	8	0.0001

Dependent variable: D(LGDP)

Excluded	Chi-sq	df	Prob.
D(LAGRI)	7.733865	2	0.0209
D(LGCF)	0.991275	2	0.6092
D(LGE)	1.882239	2	0.3902
D(RINT)	8.468629	2	0.0145
All	19.06800	8	0.0145

Dependent variable: D(LGCF)

Excluded	Chi-sq	df	Prob.
D(LAGRI)	2.090690	2	0.3516
D(LGDP)	2.279869	2	0.3198
D(LGE)	0.291244	2	0.8645
D(RINT)	5.936922	2	0.0514
All	8.607192	8	0.3765

Dependent variable: D(LGE)

Excluded	Chi-sq	df	Prob.
D(LAGRI)	0.539125	2	0.7637
D(LGDP)	0.548167	2	0.7603

D(LGCF)	0.824641	2	0.6621
D(RINT)	2.291952	2	0.3179
All	2.738322	8	0.9497

Dependent variable: D(RINT)

Excluded	Chi-sq	df	Prob.
D(LAGRI)	0.615480	2	0.7351
D(LGDP)	0.997841	2	0.6072
D(LGCF)	2.123842	2	0.3458
D(LGE)	0.110660	2	0.9462
All	4.061066	8	0.8516

EQUATION 4.5

VEC Granger Causality/Block Exogeneity Wald Tests
Date: 10/29/18 Time: 10:25
Sample: 1975 2016
Included observations: 39

Dependent variable: D(LAGRI)

Excluded	Chi-sq	df	Prob.
D(REER)	0.119326	1	0.7298
D(LAX)	2.900967	1	0.0885
D(LGCF)	0.177492	1	0.6735
D(LGDP)	0.116377	1	0.7330
D(LGE)	4.289102	1	0.0384
All	9.631853	5	0.0864

Dependent variable: D(REER)

Excluded	Chi-sq	df	Prob.
D(LAGRI)	0.647055	1	0.4212
D(LAX)	1.483316	1	0.2233
D(LGCF)	2.331362	1	0.1268
D(LGDP)	4.317804	1	0.0377
D(LGE)	0.314334	1	0.5750
All	14.83310	5	0.0111

Dependent variable: D(LAX)

Excluded	Chi-sq	df	Prob.
D(LAGRI)	0.899312	1	0.3430
D(REER)	0.446528	1	0.5040
D(LGCF)	2.157026	1	0.1419
D(LGDP)	0.117225	1	0.7321
D(LGE)	1.476767	1	0.2243
All	2.742216	5	0.7397

Dependent variable: D(LGCF)

Excluded	Chi-sq	df	Prob.
D(LAGRI)	2.759949	1	0.0967
D(REER)	0.887920	1	0.3460
D(LAX)	0.406912	1	0.5235
D(LGDP)	0.268066	1	0.6046

D(LGE)	0.898144	1	0.3433
All	3.617055	5	0.6058

Dependent variable: D(LGDP)

Excluded	Chi-sq	df	Prob.
D(LAGRI)	1.070484	1	0.3008
D(REER)	4.750831	1	0.0293
D(LAX)	0.569971	1	0.4503
D(LGCF)	0.046240	1	0.8297
D(LGE)	0.062822	1	0.8021
All	5.730731	5	0.3333

Dependent variable: D(LGE)

Excluded	Chi-sq	df	Prob.
D(LAGRI)	0.095554	1	0.7572
D(REER)	0.051051	1	0.8212
D(LAX)	1.441859	1	0.2298
D(LGCF)	0.121278	1	0.7277
D(LGDP)	0.004256	1	0.9480
All	2.298650	5	0.8065

EQUATION 4.6

VEC Granger Causality/Block Exogeneity Wald Tests
Date: 10/29/18 Time: 10:18
Sample: 1975 2016
Included observations: 39

Dependent variable: D(LAGRI)

Excluded	Chi-sq	df	Prob.
D(LCPI)	7.130204	2	0.0283
D(LGDP)	9.754935	2	0.0076
D(LGE)	18.10344	2	0.0001
D(LM2)	1.397849	2	0.4971
D(REER)	2.077537	2	0.3539
All	31.05874	10	0.0006

Dependent variable: D(LCPI)

Excluded	Chi-sq	df	Prob.
D(LAGRI)	0.006027	2	0.9970
D(LGDP)	0.669915	2	0.7154
D(LGE)	2.435919	2	0.2958
D(LM2)	4.424524	2	0.1095
D(REER)	1.518447	2	0.4680
All	8.033253	10	0.6256

Dependent variable: D(LGDP)

Excluded	Chi-sq	df	Prob.
D(LAGRI)	5.703253	2	0.0578
D(LCPI)	33.88889	2	0.0000
D(LGE)	14.17367	2	0.0008
D(LM2)	8.412374	2	0.0149
D(REER)	6.987928	2	0.0304
All	70.04030	10	0.0000

Dependent variable: D(LGE)

Excluded	Chi-sq	df	Prob.
D(LAGRI)	1.118450	2	0.5717
D(LCPI)	3.865956	2	0.1447
D(LGDP)	0.524242	2	0.7694
D(LM2)	6.489979	2	0.0390

D(REER)	3.164926	2	0.2055
All	13.19225	10	0.2131

Dependent variable: D(LM2)

Excluded	Chi-sq	df	Prob.
D(LAGRI)	5.662939	2	0.0589
D(LCPI)	6.308251	2	0.0427
D(LGDP)	1.618466	2	0.4452
D(LGE)	1.923255	2	0.3823
D(REER)	0.639691	2	0.7263
All	21.92527	10	0.0155

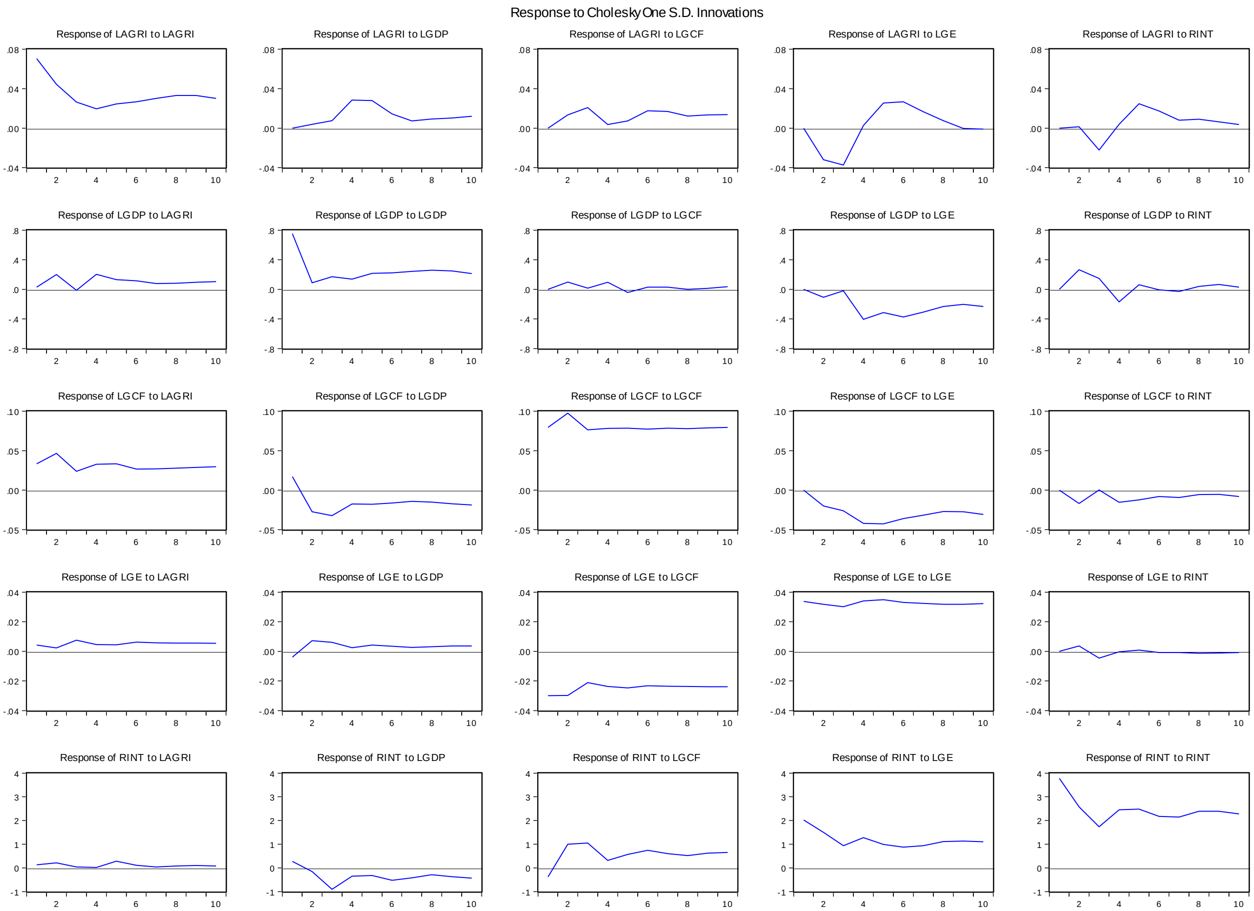
Dependent variable: D(REER)

Excluded	Chi-sq	df	Prob.
D(LAGRI)	1.961382	2	0.3751
D(LCPI)	1.996802	2	0.3685
D(LGDP)	1.295774	2	0.5232
D(LGE)	2.328392	2	0.3122
D(LM2)	0.143105	2	0.9309
All	10.21615	10	0.4217

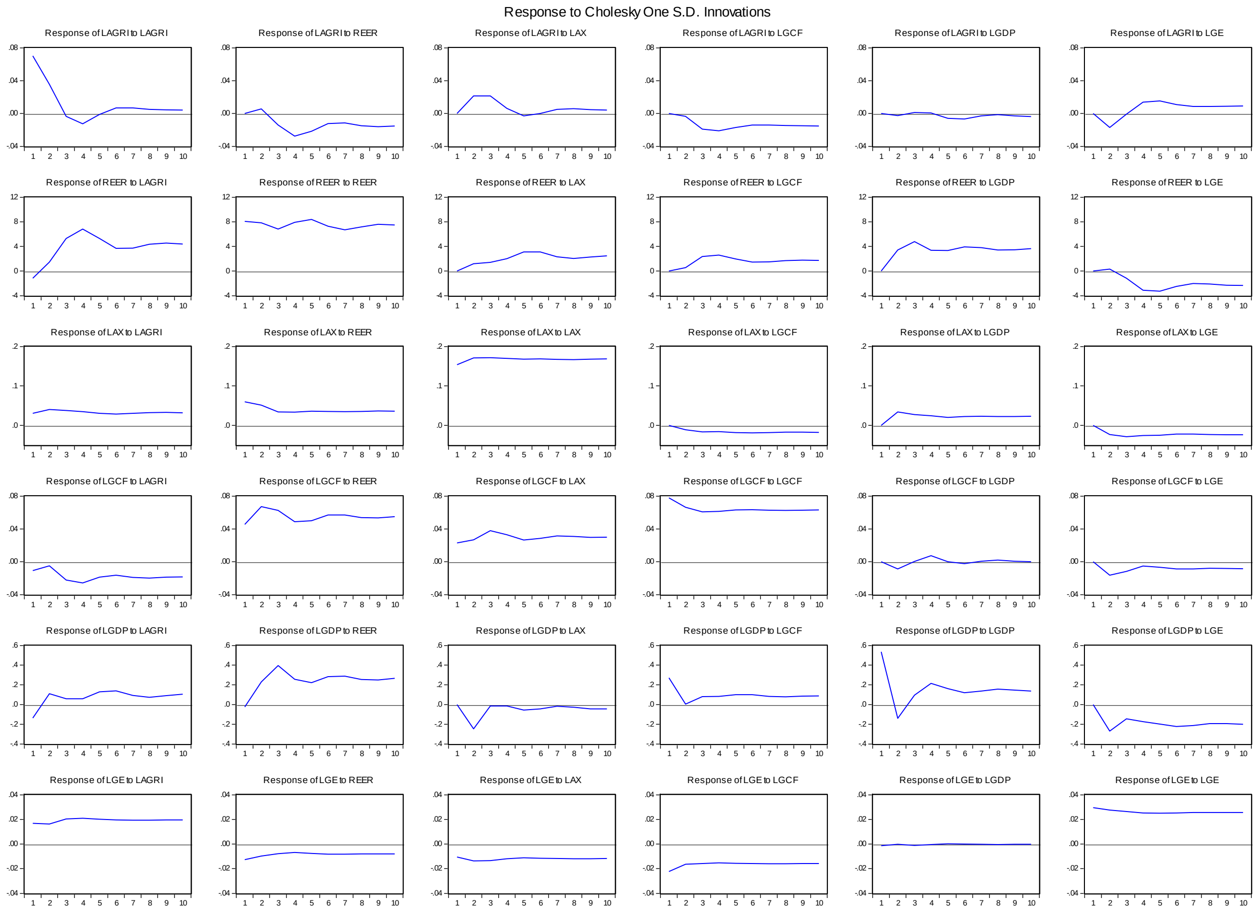
APPENDIX 6

IMPULSE RESPONSES

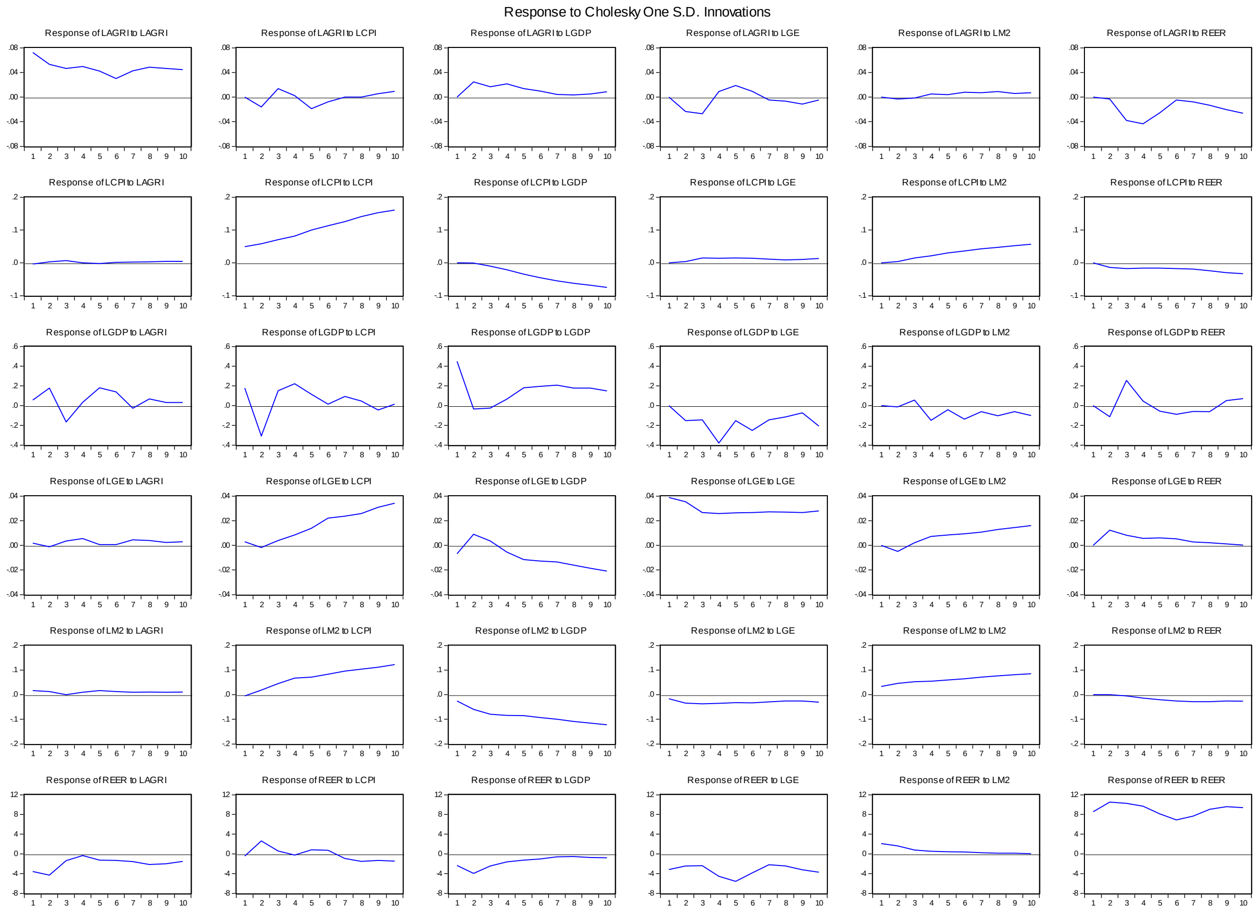
EQUATION 4.4



EQUATION 4.5


Response to Cholesky One S.D. Innovations
Response of LAGRI to LAGRI
Response of LAGRI to REER
Response of LAGRI to LAX
Response of LAGRI to LGCF
Response of LAGRI to LGDP
Response of LAGRI to LGE
Response of REER to LAGRI
Response of REER to REER
Response of REER to LAX
Response of REER to LGCF
Response of REER to LGDP
Response of REER to LGE
Response of LAX to LAGRI
Response of LAX to REER
Response of LAX to LAX
Response of LAX to LGCF
Response of LAX to LGDP
Response of LAX to LGE
Response of LGCF to LAGRI
Response of LGCF to REER
Response of LGCF to LAX
Response of LGCF to LGCF
Response of LGCF to LGDP
Response of LGCF to LGE
Response of LGDP to LAGRI
Response of LGDP to REER
Response of LGDP to LAX
Response of LGDP to LGCF
Response of LGDP to LGDP
Response of LGDP to LGE
Response of LGE to LAGRI
Response of LGE to REER
Response of LGE to LAX
Response of LGE to LGCF
Response of LGE to LGDP
Response of LGE to LGE

EQUATION 4.6


Response to Cholesky One S.D. Innovations
Response of LAGRI to LAGRI
Response of LAGRI to LCPI
Response of LAGRI to LGDP
Response of LAGRI to LGE
Response of LAGRI to LM2
Response of LAGRI to REER
Response of LCPI to LAGRI
Response of LCPI to LCPI
Response of LCPI to LGDP
Response of LCPI to LGE
Response of LCPI to LM2
Response of LCPI to REER
Response of LGDP to LAGRI
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Response of LGDP to LGDP
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Response of LGDP to LM2
Response of LGDP to REER
Response of LGE to LAGRI
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Response of LM2 to REER
Response of REER to LAGRI
Response of REER to LCPI
Response of REER to LGDP
Response of REER to LGE
Response of REER to LM2
Response of REER to REER