ANALYSING THE RELATIONSHIP BETWEEN GOVERNMENT EXPENDITURE IN AGRICULTURE, THE VALUE OF AGRICULTURAL PRODUCTION, AND OTHER SELECTED VARIABLES IN SOUTH AFRICA FOR THE PERIOD 1983-2019

BY

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DECLARATION

I, Etian Ngobeni, declare that the mini-dissertation entitled: **ANALYSING THE RELATIONSHIP BETWEEN GOVERNMENT EXPENDITURE IN AGRICULTURE, THE VALUE OF AGRICULTURAL PRODUCTION, AND OTHER SELECTED VARIABLES IN SOUTH AFRICA FOR THE PERIOD 1983-2019:** submitted to the University of Limpopo in partial fulfilment for the requirement of degree on Master of Science in Agricultural Economics, has not been submitted before at the University of Limpopo or any other institution and all sources or materials used have been duly acknowledged.

05/10/2022

Signature Date

DEDICATION

I sincerely dedicate this mini-dissertation to my parents Elinah Ngobeni and Jonas Ngobeni, My grandmother Elizabeth Ngobeni, and my aunt Mphephu Ngobeni.

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ABSTRACT

Agricultural production measures the performance and efficiency of a country's agricultural sector. The state of agricultural production can be assessed through the value of agricultural production, which is a product of agricultural gross production and output prices in monetary terms. The study examines the relationship between the value of agricultural production, government spending on agriculture, and other selected variables. Annual data for the value of agricultural production, government expenditure in agriculture, consumer price index, average annual rainfall, food import value, and population from 1983 to 2019 were collected from different sources and were used in the analysis for this study.

The Johansen cointegration test was used to determine the existence of a long-run relationship between the value of agricultural production and selected variables by using both the trace and eigenvalue tests. The results indicated that there is a long-run relationship among the variables. The study further used the Granger causality test to check the causality between the value of agricultural production and government expenditure in agriculture. The results show that there is no causal effect between the two variables. Lastly, the study used a Vector autoregressive (VAR) model to determine the relationship between the value of agricultural production and selected variables. The results of the VAR model indicated that government expenditure on agriculture, average annual rainfall, food import value, and population positively affect the value of agricultural production. The study also found that the consumer price index negatively affects the value of agricultural production.

The study recommends that the government increase its spending on the agricultural sector, which could be in the form of research investment in technologies such as climate-smart agricultural technologies. Additionally, the study recommends that policymakers should review the monetary policy of South Africa to ensure price stability and prevent inflation. Lastly, the study recommends that the South African government should discourage imports and encourage South African agricultural producers to produce more major imported food products.

Keywords: Value of agricultural production, Government expenditure in agriculture, Johansen cointegration, Granger causality, VAR

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AAR	Annual Average Rainfall
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ADF	Augmented Dickey-Fuller
AGRISETA	Agricultural Sector Education Training Authority
AIC	Akaike Information Criterion
AR	Autoregressive
ARC	Agricultural Research Council
ARDL	Autoregressive Distributed Lag
CASP	Comprehensive Agricultural Support Program
CE	Cointegrating Equations
CPI	Consumer Price Index
DAFF	Department of Agriculture, Forestry, and Fisheries
DALRRD	Department of Agriculture, Land Reform, and Rural Development
DAO	Decentralised Autonomous Organisation
Df	Degrees of Freedom
FAO	Food and Agricultural Organisation
FDI	Foreign Direct Investment
FIV	Food Import Value
FPE	Final Prediction Error
GDP	Gross Domestic Product
GEA	Government Expenditure in Agriculture
HQ	Hannan-Quinn Information Criterion
ICT	Information and Communications Technology
IMF	International Monetary Fund
ITA	International Trade Administration
LR	Likelihood Ratio
mm	Millimetre
NT	National Treasury
OECD	Organisation of Economic Cooperation and Development
OLS	Ordinary Least Squares

PG	Population
R	Rand
SARB	South African Reserve Bank
SAWS	South African Weather Services
SC	Schwarz Criterion
STATS SA	Statistics South Africa
UN	United Nations
US	United States
VAP	Value of Agricultural Production
VAR	Vector Autoregressive
VECM	Vector Error Correction Model
WB	World Bank
WTO	World Trade Organisation

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CHAPTER 1
INTRODUCTION

1.1 Background of the study

1.1.1 The importance of agricultural production

According to various studies (Greyling *et al*., 2015; Bernstein, 2013; Mutaudeen and Hussainatu, 2014), agricultural production in South Africa has been fluctuating over the years. In some years, agricultural production was stable, while in other years it was increasing either at an increasing or decreasing rate. Agricultural production measures the performance and efficiency of a country's agricultural sector (Rahman and Anik, 2020). The level of agricultural production also gives an insight depth into the importance and relevance of the agricultural sector when compared with other sectors (Liebenberg *et al.,* 2010). Moreover, agricultural production is considered the most significant primary condition for economic production and is a key to improving social development (Liu *et al.,* 2021). The role of agricultural production in sustainable economic development is well established across countries (Ahmed *et al*., 2019). When agricultural production output declines, the prices of products at the farm-gate rise (Altson *et al.,* 2009) as the availability of products declines and scarcity arises. An increase in the prices of commodities at farm-gate causes an increase in the value of agricultural production (explained further in section 1.1.2) given a scenario where production output is maintained or improved and prices are determined by market forces in the situation where the government does not intervene directly to influence prices (Karfakis *et al.,* 2011). Therefore, the importance of agricultural production output lies in its contribution to determining the prices of agricultural products and ultimately the efficiency of the whole country's agricultural sector. An increase in agricultural production output ensures that small and medium-scale farmers get better opportunities which ultimately increases the incomes of the poorest groups in the society and further enhances the contribution of the agricultural sector to national economic growth (Brownson *et al.,* 2012).

1.1.2 The value of agricultural production in South Africa

In South Africa, just like in most developing countries globally, food insecurity is a central concern in which citizens always fail to afford and access nutritious food (FAO, 2015). The value of agricultural production fluctuates from time to time due to changes in economic factors such as government expenditure (Jefferson *et al*., 2022). A fluctuating value of agricultural production entail instant and rapid high and low prices of agricultural products at farm gate, and these fluctuations imply different effects to the livelihood of consumers and producers. In scenarios where the value of agricultural production instantly become high, prices of food at retail stores relatively become high and expose consumers to financial vulnerability. Consumers and producers have conflicting objectives in which consumers aim at buying agricultural products at lower prices while consumers aim at selling products at higher prices for profit maximisation (Vasić *et al.,* 2019). Subsequently, a high value of agricultural production is advantageous for producers and detrimental to consumers. The value of agricultural production is found by multiplying the total agricultural production output by the prices of commodities at farm-gate (FAO, 2021) meaning that the value of agricultural production is gross agricultural output expressed in monetary terms. In 2003 and 2004, the South African total value of agricultural production was estimated at R72 million (Kirsten *et al*., 2009). According to DAFF (2020), the value of agricultural production in South African context is derived from the prices of field crops, horticultural crops, and livestock products. Some studies (Lencucha *et al*., 2020; MacDonald *et al*., 2015; Taiba, 2014) argue that prices of agricultural commodities should be raised for farmers' incentives to expand production. However, increasing the prices of agricultural commodities also has significant consequences as it makes staple foods to be more expensive for poor sections of the population. Staple food prices were extremely high in the periods 1991/2; 1994/5; 2002/3; and then again in 2008/9 (Kirsten, 2015). Increasing farm prices redistributes income towards the agricultural sector, where the savings ratio is lower than in the rest of the economy (Cervantes-Godoy and Dewbre, 2010). Moreover, raising agricultural prices leads to lagged wage increases in the other sectors of the economy and at least a temporary decline in industrial profits and the rate of industrial growth (Zainab and Umar, 2015). Agricultural production output, the value of agricultural production and government expenditure are all intertwined as further elaborated in section 1.1.3.

1.1.3 Government expenditure in agriculture in South Africa

Government expenditure on agriculture is globally accepted as a crucial technique for increasing agricultural production (Wielechowski, 2019). To stabilize the value of agricultural production, the government allocates a budget to the agricultural sector

(Tsakok and Bruce, 2007). Government budgets should be balanced among different economic sectors (Mainali, 2021). However, there might be no budget balance in most developing countries. In South Africa, the agricultural sector is barely treated as other economic sectors in budgetary policies (Meijerink and Roza, 2007) and thus resulting in many agricultural market failures. The share of government expenditure on agriculture in the total South African government expenditure is lower than the share of agriculture in the economy (Ebenezer *et al*., 2019). Government expenditure in agriculture accounted for 1% of the total government expenditure in 2019/20 (STATS SA, 2021). The South African agricultural sector contributed a share of 2.4% to the economy in the period 2020/21 (STATS SA, 2021). The allocation of government expenditure on agriculture is of essential importance when contemplating the importance of food produced through agriculture and the share it has on the whole economy. The total budget allocated to the agricultural sector increased from R1.7 billion in 2001/2002 to R5.3 billion in 2014/2015 (National Treasury, 2016). In 2016 it was recorded that the budget that is allocated to the agricultural sector had stabilized. However, it was projected that the pressure on the fiscal policy was set to continue to limit any additional expenditure in the agricultural sector by the government for the years after 2016, which would likely affect service delivery. The government had a total budget of R1.9 trillion in 2019/20, and the agricultural sector received a share of R24 billion (National Treasury, 2021).

The South African government expenditure was projected to increase at an average annual rate of 4.5% from R6.8 billion in 2017 to R7.8 billion in 2020/2021 (STATS SA, 2021). The government funds about 80% of the country's agricultural research to find new agricultural strategies for a better level of production output. Moreover, 56% of the projected expenditure was for entities and conditional grants to provinces, which increased at an annual rate of 4.6% from R3.8 billion in 2017 to R4.4 billion in 2020/2021 (STATS SA, 2021). In the South African agricultural sector, compensation of employees takes R7 billion of the total expenditure over the medium-term. Additionally, the agricultural sector receives an additional R40 million to upgrade infrastructure and necessary equipment for analytical services laboratories in Pretoria and Stellenbosch (ARC, 2019).

1.1.4 Determinants of government expenditure in South Africa

Countries spend for different reasons, one of which is economic growth (Oladele *et al.,* 2017). Government expenditure and its patterns are determined by complex factors as financial conditions and cultural, political, and economic factors (Fan and Rao, 2003). There are drivers of government expenditure in the economy and specific sectors. Some of the drivers of government expenditure include gross domestic product, government revenue, government debt, and fixed capital formation by the government (Mdluli *et al*., 2019). The ability of a country to spend depends on its willingness and ability to borrow from domestic and international sources and its own capacity to generate revenues (IMF, 2021). Maluleke (2018) identified population growth, poverty reduction, wage rate, trade openness, urbanisation, national income, and inflation rate as the drivers of government expenditure in South Africa. For government expenditure to be useful, it should be allocated to sectors such as agriculture since drivers of government expenditure emerge at the sectoral level (Zavale *et al*., 2011). While there are drivers of government expenditure, there are also obstacles that negate governments from spending (Wu *et al.,* 2010). Mdluli *et al.* (2019) records that some of the obstacles against government expenditure in South Africa include the high unemployment rate which further reduces the revenue generated within the economy. Government expenditure is influenced by the need to eliminate economic inefficiencies that are caused by market failures (Curristine *et al.,* 2007).

1.2 Problem statement

Economic growth in less developed countries is enhanced using government expenditure as an important instrument (Mapfumo *et al.,* 2012) and this translates as well to sectoral expenditure and growth. With the same spending goals for agriculture and given the general consensus that the South African agricultural sector is poised for job creation (Allen *et al.*, 2021), a lot more has to be understood in the context of government spending in the agricultural sector and agricultural production output. Ebenezer *et al.* (2019) state that government expenditure in agriculture is of vital importance for agricultural productivity. Generally, it is anticipated that improved agricultural productivity will have a positive impact on a nation’s food security. According to Iganiga and Unemhilim (2011), various factors influence the growth in the value of agricultural production. These factors compass education, infrastructure, inflation, rainfall, and industrialization. In the context of South Africa, empirical studies on the determinants of the value of agricultural production are very few. Although a study by Ebenezer *et al*. (2019) analysed the relationship between agricultural government spending and agricultural production output, the research did not consider other factors indicated in Iganiga and Unemhilin (2011) except for industrialisation. This study also differs from Ebenezer *et al.* (2019) in that, the present study analyses the value of agricultural production instead of the focus of Ebenezer *et al*. (2019) on agricultural production output. The value of agricultural production in monetary terms at farm-gate is obtained by multiplying gross production with output prices (FAO, 2021). According to OECD (2020), the value of agricultural production in South Africa has been fluctuating. A fluctuating value of agricultural production negatively affects the value adding/processing sectors of agriculture as well as the manufacturing sector and impedes economic growth. Therefore, it is important to monitor the movement of that variable (value of agricultural production) in time. Additionally, a fluctuating value of agricultural production forces households to rely on cheaper less nutritious food (Karfakis *et al.,* 2011). Moreover, a fluctuating value of agricultural production negatively affect disadvantaged farmers because most of them do not have enough financial resources to sustain such unpredictability (Huka *et al*., 2014). This study will, therefore, fill the gap in knowledge regarding the fluctuations of the value of agricultural production over time by adding literature on the analysis of various factors that influence the value of agricultural production with emphasis on government spending in agriculture in South Africa.

1.3 Rationale of the study

Agriculture plays a significant role in the process of economic development and can significantly contribute to household food security in South Africa (DAFF, 2019). According to STATS SA (2020), a census conducted in 2017 on commercial agriculture showed that South Africa has 40122 highly capitalised farms. The smallholder sector comprises an estimated 1 762 000 smallholder farmers (Von Loeper and Blignaut, 2018). The agricultural sector is known for generating jobs, poverty eradication, and improving the livelihoods of rural households in the Sub-Saharan Africa region (FAO, 2016). Employment in the South African agricultural sector is estimated to be about 5% of the total labour force (World Bank, 2020). With this notion, the South African government has introduced various policies and programs intending to strengthen the agricultural sector to continue doing its significant economic role. One of the policies is a fiscal policy which is a tool of economic management which encourages the use of public spending to achieve stability in the economy (Edeh *et al*., 2020). The Fiscal policy involves governments' use of its public expenditure and revenue master plans to attain advantageous effects while negating undesirable effects on the county's employment, gross output, and productivity.

Government spending on agriculture is aimed at enhancing agricultural production. Omabitan and Khanal (2022) identified government spending as one of the main drivers of farm production output. Development economists consider production growth in the agricultural sector as crucial if the agricultural output is to increase significantly at an adequately expeditious rate to meet the growing demand for food (Black and Gerwel, 2014). The inability to analyse the impact of government spending can result in the negative effect of ineffective spending overwhelming the positive effects (Devarajan *et al*., 1996). In South Africa, several studies (Chipaumire *et al.,* 2014; Molefe and Choga, 2017; Odhiambo, 2015), have analysed the impact of government spending on the overall economy neglecting to examine the effect it has on public sectors like agriculture. According to Moreno-Dodson (2008), government spending may be unproductive and further reduce the production ability of subsectors. Hence it is necessary to analyse the effect of government spending in agriculture on the value of agricultural production in South Africa, given that there is limited literature for the period evaluated in this study.

1.4 Scope of the study

1.4.1 Aim of the study

The study aims to examine the relationship between the value of agricultural production, government spending in agriculture, annual average rainfall, consumer price index, food import value, and population.

1.4.2 Objectives of the study

The objectives of this study are to:

I. Analyse the short-run and long-run relationship between government spending in agriculture and the value of agricultural production.

II. Determine the causality between government spending in agriculture and the value of agricultural production.
III. Determine the relationship between the value of agricultural production and selected independent variables: government spending in agriculture, annual average rainfall, consumer price index, food import value, and population.

1.4.3 Hypotheses

I. There is no significant long-run and short-run relationship between government spending in agriculture and the value of agricultural production.
II. There is no causality between government spending in agriculture and the value of agricultural production.
III. There is no relationship between the value of agricultural production and selected independent variables: government spending in agriculture, annual average rainfall, consumer price index, food import value, and population.

1.5 The importance of the study

The South African agricultural sector contributes significantly to the livelihood of people and economic growth. As South Africa continues to work towards economic development, new knowledge on factors that influence economic growth at the sectoral level is needed. This study explores factors such as government expenditure in agriculture, consumer price index, annual average rainfall, food import value, and population which affect the value of agricultural production in South Africa. Therefore, this study will fill the gap in the literature and add to the studies that have not considered the effect of the aforementioned factors towards the value of agricultural production. Additionally, this study will give necessary information to the government policy makers on the impact that government spending in agriculture had on the value of agricultural production in South Africa from 1983 to 2019. Furthermore, the study will also give detailed information on the impact of other factors such as consumer price index, average rainfall, food import value, and population growth towards the value of agricultural production in South Africa. The government will get to understand how it should spend towards the agricultural sector in the future to enhance the value of agricultural production.

1.6 Structure of the study

This study is made up of six chapters in with which chapter 1 provides the introduction. Chapter 2 gives a historic trend analysis of the selected variables in South Africa. Chapter 3 gives detail into the theoretical and empirical literature related to the study. Chapter 4 explores the methodologies that are used in this study. In chapter 5, results and empirical analysis of the findings are discussed. Lastly, chapter 6 gives a summary and concludes the findings. Furthermore, chapter 6 gives an overview of the recommendations together with the limitations of the study and future research suggestions.

CHAPTER 2

OVERVIEW AND HISTORIC TRENDS OF SELECTED VARIABLES IN SOUTH AFRICA

2.1 Introduction

In this chapter, an overview of the selected variables relevant to this study is given based on available literature. Historic trends in South Africa on the selected variables that affect the value of agricultural production are illustrated using graphs and diagrams. Furthermore, explanations of the graphs and diagrams are given in this chapter. Since these variables affect the value of agricultural production, it is crucial to analyse their historic trends/behaviour.

2.2 Trends of selected variables

2.2.1 Value of agricultural production

The value of agricultural production in South Africa was R15 000 million in 1987 (Kirsten *et al.,* 1994). Even though the South African value of agricultural production was fluctuating in historical years, it increased between the period 1999 to 2018. DAFF (2017) recorded that the value of agricultural production in 2015 was R233 237 million compared to R220 983 million in 2014 which was an increase of 5.5%. The value of agricultural production increased by 15.9% in 2020 from a value of R287 395 million to a value of R332 953 million (DALRRD, 2020). The increase in the value of agricultural production between 2019 and 2020 is associated with an increase in the value of field crops.

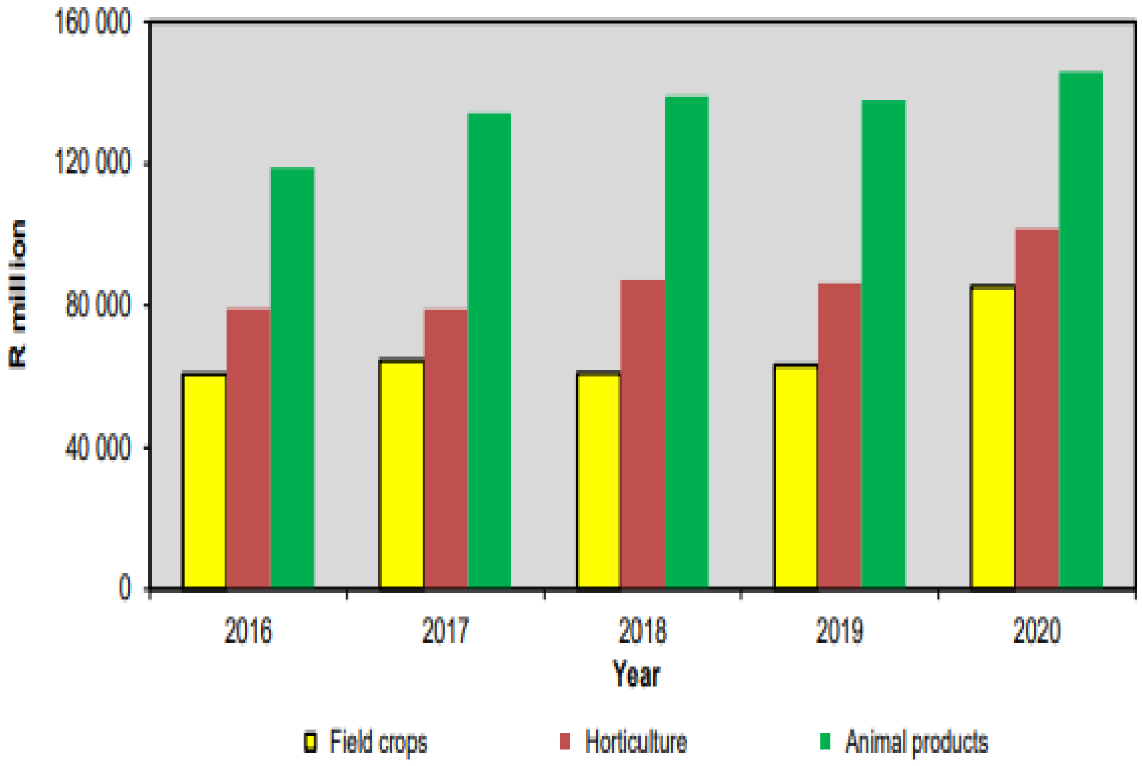

Figure 2.1: Value of agricultural production (2016-2020)

Source: DALRRD (2020)

Figure 2.1 shows the value of agricultural production based on field crops, horticulture, and animal products for the period 2016 to 2020. According to figure 2.1, animal products contribute a larger share towards the value of agricultural production as compared to field crops and horticulture in South Africa. From 2016 to 2020, animal products have contributed more than R120 000 million towards the gross value of agricultural production in each year. Subsequently, Horticulture has contributed between R80 000 million and R120 000 million value of production towards the gross value of agricultural production in the period 2016 to 2020. Moreover, field crops have contributed less than R80 000 million towards the gross value of agricultural production in South Africa between 2016 and 2020. Meaning that field crops contribute less towards the value of agricultural production in South Africa as compared to horticultural crops and livestock products. According to DALRRD (2020), the gross value of animal products contributed 43,8% to the total gross value of agricultural production, while horticultural products and field crops contributed 30,5% and 25,7%, respectively.

2.2.2 Government expenditure in agriculture

In South Africa, the total government expenditure on agriculture inclusive of forestry and fisheries has expanded almost threefold between 2003 and 2014 (Visser and Ferrer, 2015). There was an annual increase of 10.8% which is from R5.77 billion in 2003 to R16.97 billion in 2014 (World Bank, 2015). From 2003, government expenditure on agriculture has increased by 15% annually until 2008/9. After the 2008/9 period, the growth resumed by 8.9% annually until 2014. Figure 2.2 shows the growth trend in government expenditure in agriculture from 1982 to 2014.

Figure 2.2: Annual Government expenditure in agriculture trend (1982-2014)

Source: SARB, 2021

Government expenditure in agriculture has been fluctuating between 1982 and 2014 in South Africa based on figure 2.2. From 2004/5, the government introduced the Comprehensive Agricultural Support Program (CASP) to promote the provision of post-settlement support services to land reform beneficiaries which enhanced agricultural businesses (DAO, 2004). Since CASP was implemented, an aggregated amount of R750 million has been allocated to this program (DALRRD, 2021). This led to a stronger focus on agricultural rural development and farmer settlement and financing. Hence the trend of government expenditure in agriculture after 2004 started to increase gradually even though it would decline in some years and instantly increase.

2.2.3 Average annual rainfall

Rainfall in South Africa is variable spatially and temporally (Morris *et al.*, 2005). Most of the rain in South Africa is received in the summer seasons. The average annual rainfall from 1936 to 1999 was 450 mm (Tennant and Hewitson, 2002). Rainfall was above average in the 1970s, the late 1980s, and mid to late 1990s, and below average in the 1960s and the early 2000s, reverting to average towards 2010 (Kruger and Nxumalo, 2017).

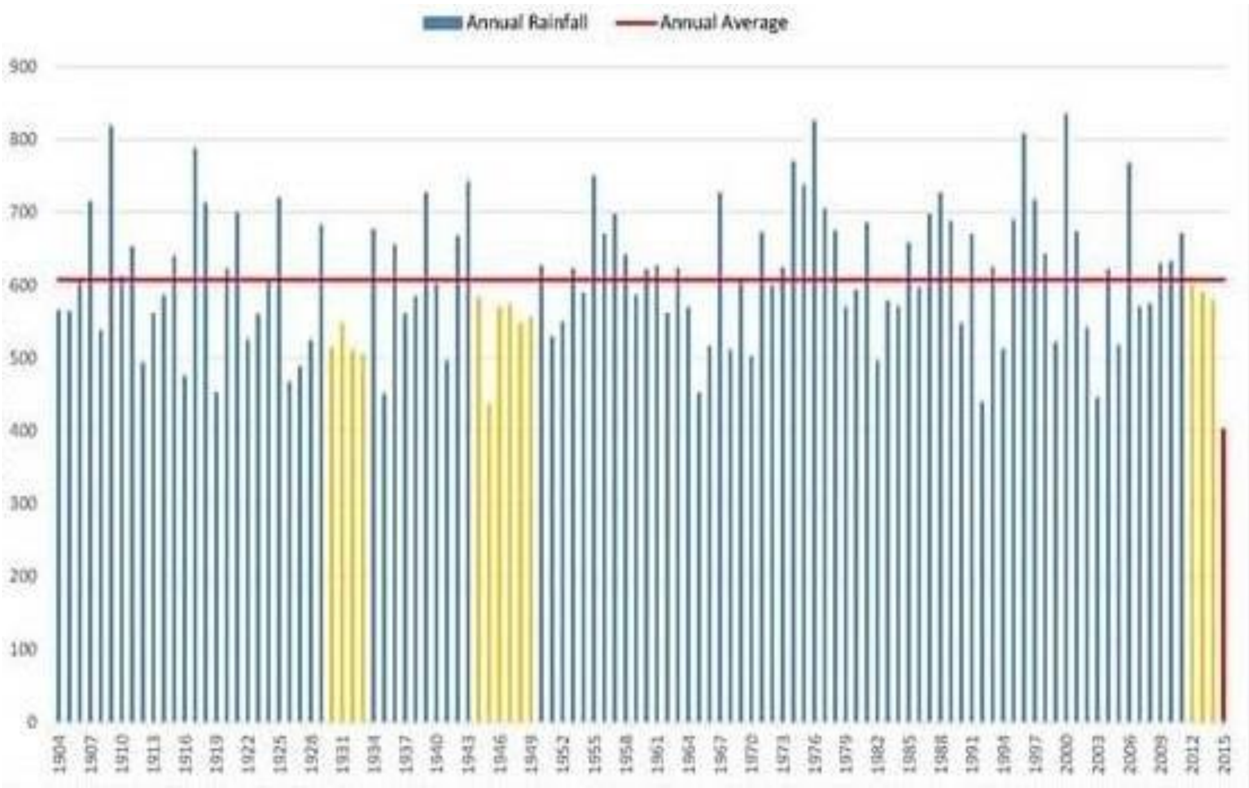

Figure 2.3: Annual average rainfall in South Africa (1904-2015)

Source: SAWS (2016)

Figure 2.3 shows the average annual rainfall of South Africa for the period 1904 to 2015 and the bars show the average rainfall per year. Based on figure 2.3 it is evident that the rainfall in South Africa is variable as in some years it goes above the average level while in other years it goes below the average level. However, the South African rainfall based on figure 2.3 shows below-average rainfall in many of the years covered in that figure.

2.2.4 Consumer price index

In the early 1980s, the consumer price index was low in South Africa (Moritz, 1994). The agricultural sector faced debt and high inflation in the early 1980s which harmed the whole economy (Vink and Van Rooyen, 2009). South Africa faced a severe drought in the early 1990s which influenced the consumer price index to be relatively high. Food prices in 1990 made an 18.6% weighting structure of the consumer price index (Oosthuizen, 2007). Figure 2.4 shows the trend in the consumer price index from the early 1980s to 2020. The consumer price index is usually high due to factors such as drought which always put pressure on agricultural production output (Quiggin, 2008).

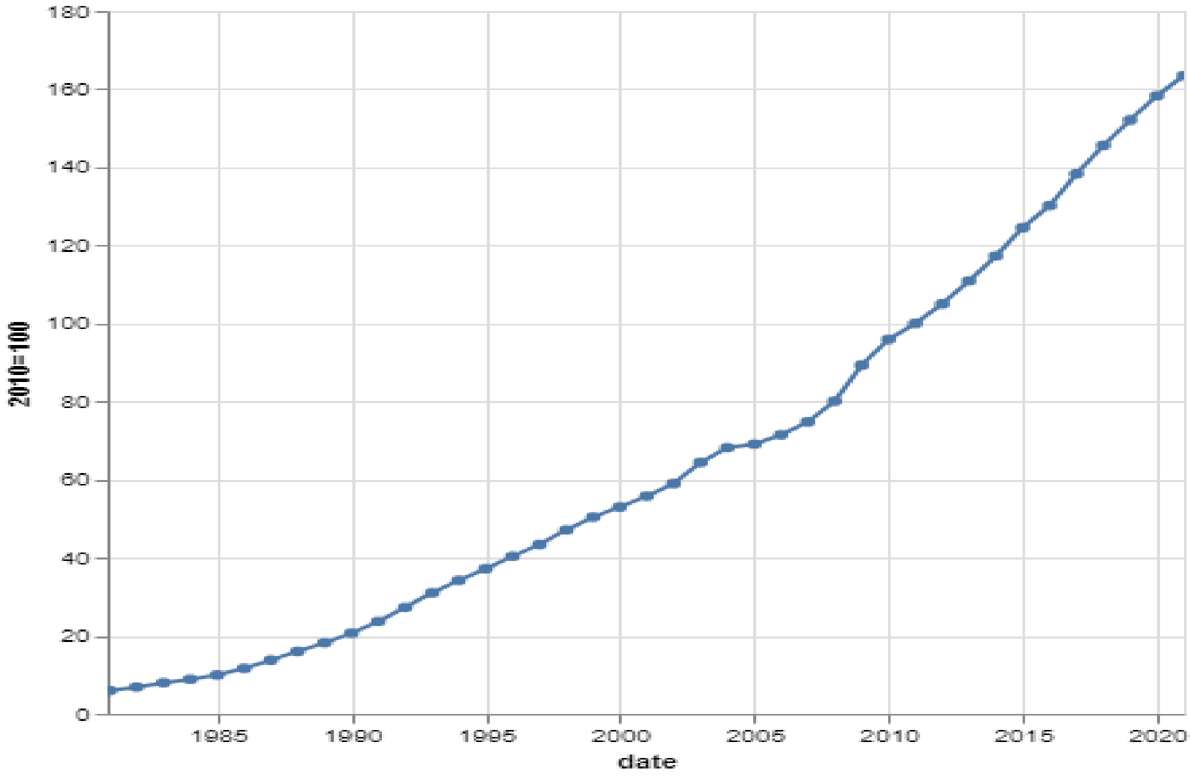

Figure 2.4: Annual Consumer price index in South Africa

Source: DALRRD, 2021

Figure 2.4 shows that the South African consumer price index was increasing at a slow rate from the early 1980s to 1990. From 1990 the consumer price index started to increase drastically until 2004 when it started stabilizing. However, in 2006 it started to increase, and then from 2008, it was increasing at an increasing rate due to the global downturn that was experienced in that period (Rena and Msoni, 2014). From 2011 to 2020, the consumer price index increased each year without declining or stabilizing.

2.2.5 Food import value

There are various reasons why South Africa imports food from other countries in different years (Potelwa *et al*., 2016). The need to import might be a result of producing less agricultural output in a certain year (Lencucha *et al.,* 2020). If South Africa produces less food in a particular year, the chances are likely to be high for it to import more food, hence making the food import value to be relatively high and vice versa. As countries continue to develop, some are faced with less production due to resource scarcity (Dong *et al.,* 2022). Subsequently, countries are mandated to import from other countries, thus increasing the food import value. According to Kirsten *et al.* (1994), food imports in South Africa had a value of R1 200 million in 1993.

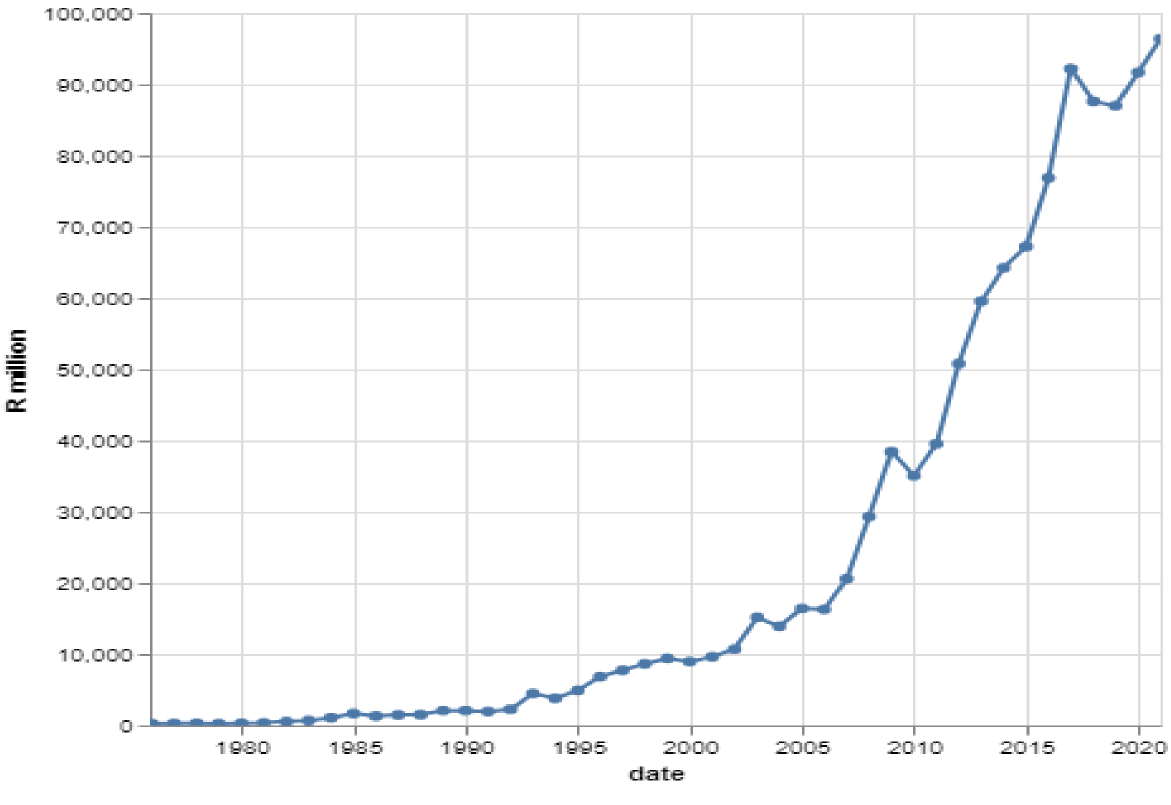

Figure 2.5: Annual food import value in South Africa

Source: DALRRD, 2021

Figure 2.5 shows that the food import value in South Africa has been fluctuating from 1980 to 2020 because there is no consistent trend. Between some years the food import value was increasing while between some years it was decreasing. Food import value started increasing at an increasing rate from 2010 to 2017. Where it eventually declined in 2018 and picked up again from 2019 to 2020. The trend of food import value based on Figure 2.5 shows that South Africa grew in importing more agricultural commodities as a result of succumbing to food import value drivers such as low agricultural production output.

2.2.6 Population

The South African population was estimated to be 59.62 million by mid-2020, 62.3% of the population was aged between 16 and 59 (STATS SA, 2020). According to AGRISETA (2016), the agricultural sector employs most people in rural areas in South Africa. The sector employs an approximately 898 000 people, which represents 5.7% of the total labour force in the country.

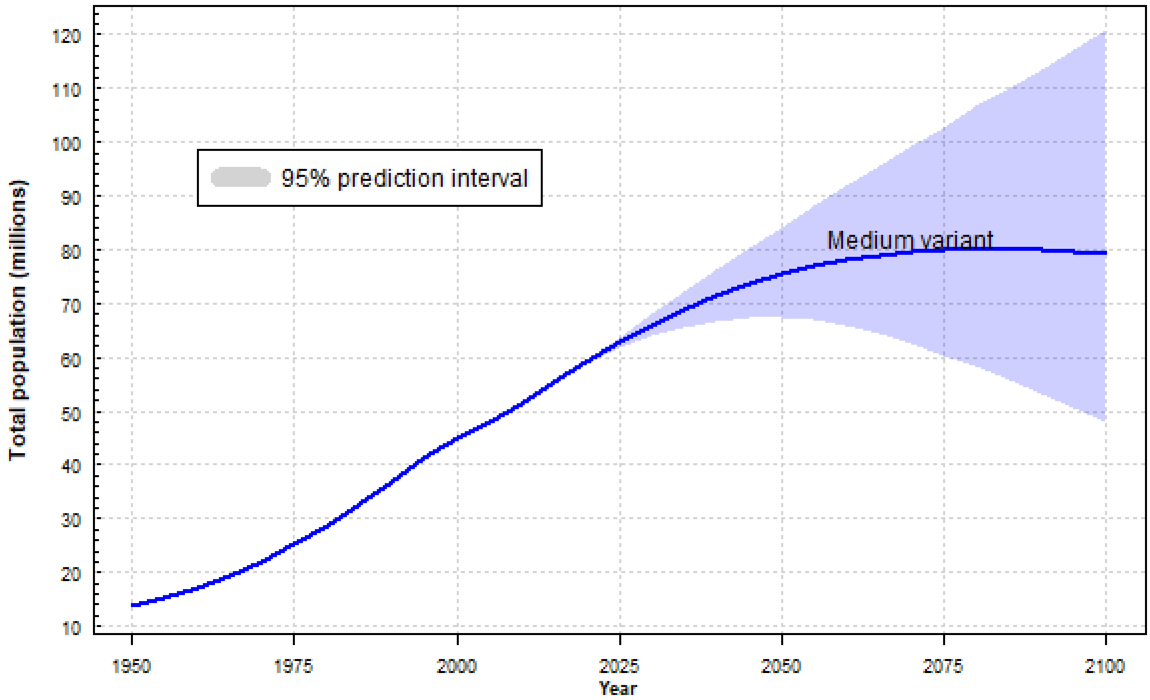

Figure 2.6: Annual population in South Africa

Source: United Nations, 2019

Figure 2.6 indicates the actual population of South Africa from 1950 to 2019 and the projected annual population of South Africa from 2020 to 2100. Based on figure 2.6, in 1950 the population of South Africa was less than 20 million. Additionally, Figure 2.6 indicates that the population has been increasing without declining over the years. However, even though the trend increases from 1950 projected to 2075, the trend is predicted that it will stop increasing and continue to be stable from 2075 to 2100 as shown in Figure 2.6.

2.3 Summary

This chapter gave an overview and historic trends of selected variables in South Africa. In addition, the chapter made use of graphical illustrations for each selected variable and further outlined details of each graph in writing based on estimated values for the past years.

Since a review of selected variables was made in this chapter, the next chapter gives a detailed literature review of the study.

CHAPTER 3
LITERATURE REVIEW

3.1 Introduction

This chapter is divided into various sections in which the first one gives definitions to the key concepts used in this study. Additionally, the chapter explores theoretical perspectives related to this study. A theoretical discussion on general issues that are linked with agricultural production is outlined in this chapter. Furthermore, the chapter gives more details on theories of government expenditure and the role of government expenditure in agricultural development in both South African and international contexts. Variables that are assumed to be affecting the value of agricultural production are also explained in this chapter. An insight into national and international empirical studies related to this study is given. Finally, a summary of the whole chapter is outlined at the end.

3.2 Definition of key concepts

3.2.1 The value of agricultural production

According to FAO (2011), the value of agricultural production is the total output of agriculture expressed in monetary terms or average purchasing power parity agricultural prices. The value of agricultural production estimates the quality of agricultural production output at the prices with relation to the specified period (Carter, 1984). Hence, the value of agricultural production signifies the value of agricultural products at the time they were produced. This study adopts the definition of the value of agricultural production as stipulated by FAO (2011).

3.2.2 Government expenditure in agriculture

Government expenditure in agriculture depicts the expenses that are incurred by the government towards the agricultural sector (Atayi *et al.*, 2020). According to Mogues and Anson (2018), government expenditure in agriculture covers expenses such as agricultural research, technology development, livestock, crop gene banks, and extension services. Government expenditure in agriculture ensures that the agricultural sector becomes efficient in production which further helps the government to achieve its economic objectives such as expanding employment opportunities (Awubare and Eyitope, 2015).

3.3 Nature of agricultural production

According to Liebenberg *et al.* (2011), the change in the size and structure of South Africa's agricultural sector and agricultural production dates back to the beginning of the 20th century. From the year 2000, the growth in crop production in South Africa has fallen as compared to the growth in the production of livestock which increased by 4.31% annually (Liebenberg *et al*., 2011). Agricultural production has become more important due to factors such as climate, population and food security (Ullah and Shivakoti, 2018). According to Oberč and Schnell (2020), most researchers in sustainable agriculture are trying to understand how to increase agricultural production by using measures that are both environmentally and economically friendly. Praburaj (2018) stipulates that expanding agricultural production and productivity leads to sustainable overall economic development, and it would be rational for governments to prioritise the development of the agricultural sector. Nevertheless, expanding agricultural production requires certain measures and policies such as government expenditure in agriculture. According to Matchaya (2020), understanding the essence of the causal process that occurs between the value of agricultural production output and government expenditure on agriculture helps to determine appropriate policy responses that can guarantee economic growth.

A study in Nigeria by Iganiga and Unemhilin (2011) analysed the impact of federal government agricultural spending on the value of agricultural production. The study used the Cobb-Douglas growth model, descriptive statistics and an econometric model to generate all empirical results. Consequently, the study found that public spending on agriculture has a positive impact on the value of agricultural production. In China, a study by Zeraibi and Mivumbi (2019) analysed the impact of public expenditure on the agricultural sector productivity using the gross output value of agriculture as a proxy variable for agricultural productivity. Additionally, the study used time series data from 1988 to 2018. To generate empirical results, the study used the Autoregressive Distributed Model (ARDL) which analysed the relationship between the value of agricultural gross output and government expenditure in the agricultural sector. The study found that government expenditure in agriculture has a positive impact on the gross output value of agriculture. Mohammed *et al.* (2017) conducted a study titled Gross Agricultural Production Valuable Land Labour Force in the Agricultural Sector and Causality of Energy Consumption in 76 countries using a dynamic panel data approach. The study used the granger causality test for empirical purposes and established that arable land and population granger cause agricultural gross production value. Ayoub and Michel (2019) analysed the impact of government spending on agricultural sector productivity in China using the value of gross agricultural output as a proxy variable for agricultural productivity. Subsequently, Ayoub and Michel (2019) used the Autoregressive Distributed Lag Model and the study found that there is a long-term relationship between government spending on agriculture and the value of gross agricultural output.

Most studies that are reviewed in this chapter are on agricultural productivity and agricultural production output since literature regarding the value of agricultural production is very limited in South Africa and internationally. Agricultural productivity measures the quantity of agricultural output that is produced given several inputs (ABARES, 2021). In addition, agricultural productivity is measured as the ratio of agricultural output to agricultural input (DAFF, 2011). Agricultural productivity expresses the total agricultural output in quantity form, while the value of agricultural production expresses the total agricultural output in monetary terms.

3.4. Government expenditure in agriculture in South Africa

Government expenditure is essential in the process of accumulating capital and improving long-term economic development (Gao *et al*., 2022). According to Chen *et al.* (2019), the nature of government expenditure varies widely across countries and has undergone significant changes over time globally. Since 1994, the government of South Africa has implemented various initiatives aimed at supporting farmers (Khapayi and Celliers, 2016). Some of these initiatives include land reform and land redistribution for agricultural development which were implemented in 2000 (Hull *et al.,* 2019). In addition, the government implemented the Comprehensive Agricultural Support Program which focuses on the provision of post-settlement for black farmers, and the Micro-Agricultural Financial Institution of South Africa which provides micro-financing to emerging farmers and smallholder farmers who are not served by the Land Bank (DAFF, 2018). Even though the Micro-Agricultural Financial institution of

South Africa is under the department of agriculture, it operates under the Land Bank. The government allocates a budget to the agricultural sector every year, then the agricultural sector ultimately distributes the budget to different initiatives and organisations which are implemented. Finally, the initiatives and organisations are accessed by farmers at the local level to acquire financial resources. According to FAO (2009), a rise in the budget that the government allocates to the agricultural sector by 10% each year ensures that over 1.6 million farmers escape poverty by living above the poverty line. An increase in government expenditure in agriculture reduces production costs which leads to an increase in production and ultimately an increase in profitability of farms, and thus ensures economic growth (Nworji *et al.,* 2012).

3.5 The Keynesian theory

According to Biza *et al*. (2015), the Keynesian model stipulates that an increase in government expenditure plays a catalytic role in domestic economic activity and vibrant private investment. The Keynesian model suggests that government expenditure is an exogenous political tool that can be used to control economic activity in the short-run (Selvanathan *et al*., 2021). Based on Keynes (1936), fiscal policy through public spending is seen as the main driver of economic growth. Hence government expenditure can be used as a strong tool that resolves all economic stagnation-related issues. However, the availability of too much government expenditure can be detrimental to private investments. Thus, South Africa is dependent mostly on foreign direct investments to sustain economic growth (Meniago and Peterson, 2013). The fact that South Africa depends on foreign direct investments means that government expenditure is not enough for maintaining all the public sectors including the agricultural sector.

According to Makin (2015), increasing government expenditure in a closed economy is followed by higher national output which further leads to more employment. Based on Keynes's theory, if governments stimulate government expenditure through fiscal policy, increased business activity will follow. And that is what most economies are always aiming to achieve. Keynes' theory further asserts that government spending improves aggregate output and paves the way for further increases in national income that result in economic growth. Public spending has a positive impact on economic growth, the causal relationship therefore runs from public expenditure to economic growth (Keynes, 1936). However, Keynes (1936) was rejected by Wagner's law which considers public expenditure as an endogenous variable that can be used to stimulate the economy rather than as a cause of growth.

3.6 Wagner’s theory

Wagner’s law was the first government expenditure theory in the history of public finance (Maribe, 2020). The law stipulated that during the process of economic development, the ratio of public expenditure in the economy tends to increase at a higher rate than that of economic growth. Wagner (1876) gives three arguments for economic development as national revenue increases. Firstly, there are needs such as capital expenditure, redistribution of income, protection, and administration, which coexist with the process of development, and they are offered by the government. Secondly, an increase in welfare and cultural expenditures on public sectors such as education and agriculture take place when national income increases. Lastly, changes in technological structures and expansion of investments in economic activities for economic development would increase the number of private monopolies. Wagner’s theory was initially well known among German economists before it was translated to English in 1958 (Manuel, 2018). According to Nyasha and Odhiambo (2019), Wagner’s theory is the most cited law among other models of government expenditure growth in the world. Adolf Wagner made a hypothetical process in examining the trend in government expenditure growth where the hypothesis is that government spending does not play a crucial role in economic development.

On the contrary, economic growth improves government expenditure. Wagner’s theory strongly believes that the causality between economic growth and government expenditure runs from economic growth to government expenditure and not vice versa as stated by the Keynesian Theory. Government expenditure will continue to stimulate economic growth to increase the well-being of its citizens. Furthermore, sustained government expenditure will result in increased investment in education, employment opportunities, a better quality of physical infrastructure, as well as sustained economic growth (Wagner, 1876). Wagner's theory is applicable in an economy where per capita income is the result of economic development. Sharma and Singh (2020) attempted to prove Wagner’s theory in India in a study titled Evidence of Wagner’s Law in India using time series data from 1960 to 2018. The study used a Vector Error Correction

Model in which government expenditure was treated as a dependent variable while gross domestic product per capita and urbanisation were treated as independent variables. The results of the Vector Error Correction Model showed that both urbanisation and the gross domestic product per capita have a positive and statistically significant impact on government expenditure in the long-run. Thus, proving that Wagner's theory holds in the economy of India. Moreover, Ibok and Bassey (2014) revisited Wagner's theory within the agricultural sector in Nigeria. Ibok and Bassey (2014) used the Johansen and Juselius cointegration test which revealed that there is a long-run relationship between agricultural capital expenditure and agricultural gross domestic product, the granger causality test proved Wagner's theory exists in the agricultural sector of Nigeria.

3.7 The role of government expenditure on agricultural development

As stated in the discussion of Keynesian theory, government expenditure is one of the most effective and prosperous measures to support economic growth. The economy is divided into different sectors and agriculture is one of them. Showing that the overall economy grows as sectors develop. The process of agricultural development generates a suitable space for realising the potential of the agricultural sector to the economy (Pawlak and Kołodziejczak, 2020). This is supported by the ideology that agricultural development is viewed as a continuous process involving the adoption of new agricultural production practices and inputs by farmers (Uremadu *et al*., 2018). Most developing countries tend to lose their participation ability in globalization due to less-developed agricultural sectors and low agricultural production which are uncompetitive in the global food market. In India, Selvaraj (1993) evaluated how the variation in public expenditure in agriculture affects the performance of the agricultural sector. The results showed that agricultural development depends on the long-term government budget allocated to the agricultural sector. Ogiogio (1995) conducted a study in Nigeria on the impact of government expenditure on total economic development for the period 1970 to 1993. The results showed that there is a significant relationship between government expenditure and economic growth. The study might be on economic development, but economic development is influenced by the growth in sectors such as agriculture. Showing that agricultural development depends critically on government expenditure. In both developing and developed countries, the transformation of the agricultural sector depends on the investments made by the central governing body.

3.8 Review of empirical studies on agricultural productivity and growth in South Africa

In South Africa, Greyling (2015) conducted a study on analysing agricultural productivity and economic growth for the period 1970-2010 using the Engle-Granger two-step test. The results showed that the consumer price index negatively affects agricultural productivity while gross capital formation, gross domestic product, labour force, and agricultural exports positively affect agricultural productivity in the long run. A study by Kargbo (2007) on the analysis of the effect of macroeconomic factors towards agricultural productivity in South Africa for the period 1957 to 2004 used a Vector Error Correction Model. The study found that money supply, interest rate, exchange rate, and consumer price index have a positive significant effect on agricultural productivity. Furthermore, the study concluded that agricultural prices are the source of macroeconomic instability in South Africa. Setshedi (2019) conducted a study on an empirical analysis of macroeconomic variables related to agricultural productivity in South Africa for the period 1975 to 2016 using a Vector Error Correction Model. The results of the study showed that public spending and agricultural exports have a positive impact on agricultural productivity. Moreover, the consumer price index and the real effective exchange rate have a negative effect on agricultural productivity.

Reviewing South African empirical literature on the value of agricultural production is a challenge. Most studies that were conducted are on agricultural productivity and agricultural production output. Hence there are insufficient empirical studies for this topic. Therefore, this study analyses factors that affect the value of agricultural production with an emphasis on government expenditure on agriculture to add knowledge to the gap.

3.9 Review of empirical studies on agricultural productivity and growth internationally

In Nigeria, a study was conducted by Muhammad-Lawal and Atte (2009) analysing agricultural production using regression analysis and descriptive statistics, using the value of agricultural production as a proxy for agricultural production. The results showed that food import value is detrimental to the value of agricultural production. Furthermore, the results showed that when government expenditure on agriculture increases, the value of agricultural production increases. Giang *et al.* (2019) conducted a study titled total factor productivity of agricultural firms in Vietnam and its relevant determinants. The study was conducted at the microeconomic level and productivity was measured as the total factor productivity of 420 agricultural enterprises. The study found that the determinants of agricultural productivity in Vietnam include size and age, the share of state and foreign ownership, export, accessibility to the internet and bank loan of firms. A study by Badar *et al*. (2007) in Pakistan on the factors affecting agricultural production used a Cobb-Douglas production function to generate empirical results. The results showed that expenditure on research is not significant while price support is significant towards agricultural production. Baba *et al.* (2010) assessed the impact of investment on agricultural growth and rural development in Himachal Pradesh of India. The study used the agricultural GDP as a proxy variable for agricultural productivity. Additionally, the study found that public and private investment in agriculture have a significant and positive relationship with agricultural productivity. Maïga *et al* (2021) analysed the effects of public expenditure on agricultural growth in Mali. The study used the Autoregressive distributed lag model and concluded that agricultural expenditure, sector employability and fertilizer consumption have significant negative effects and that education and health expenditure positively influence agricultural output. Jambo (2017) analysed the impact of government spending on agricultural growth in Zambia, South Africa, and Tanzania for the period 2000 to 2014. The study used the Vector Error Correction Model to test the impact of government spending, private investment and net trade on agricultural output growth. The results showed a negative relationship between agricultural growth and expenditure in Zambia. In Malawi, the results of the empirical analysis showed that agricultural research expenditure has a greater impact on agricultural growth, and, unlike in Zambia, there is evidence of a good relationship between agricultural growth and public expenditure. In addition, the results for South Africa showed that an increase in agricultural research expenditure increases agricultural growth.

3.10 Variables affecting the value of agricultural production

3.10.1 Government expenditure in agriculture

Expanding government expenditure in leading sectors such as agriculture drives economic activity and makes room for job creation (Ernawati *et al*., 2021). Government expenditure in agriculture is responsible for the building of roads in rural areas, silos, tractors, and other equipment for farmers, which results in increased output and improved livelihoods of the people. Government expenditure on agriculture ensures the provision of loan facilities, subsidising of farm input, and financial backing to farmers which can make the agricultural sector additionally enticing and lift entrepreneurship in agribusiness, thereby resulting in positive externalities to different sectors of the economy. Regardless of any economic system in place, the role of government expenditure cannot be overemphasised. Government expenditure by any country is usually categorised into expenditure on security/defence, health, education, foreign affairs, administration, etc. (Aigheyisi, 2011). However, this study only focuses on government expenditure on agriculture.

3.10.2 Annual average rainfall

Water is regarded as one of the key elements for agricultural production, and therefore changes in water availability may have effects on agricultural production and the value of agricultural production (Torres *et al*., 2019). Rainfall is regarded as the best source of water globally. Moreover, rainfall is associated with economic growth and is crucial in dry and poor areas that depend on rainfed agriculture (Sangkhaphan and Shu, 2020). Hence the amount of rainfall is one of the most significant factors that affect agricultural production for farmers. Agricultural production is sensitive to changes in average annual rainfall (Tabosa, 2021). According to World Bank (2021), South Africa has an estimated annual rainfall of 450mm, which is below the average of 860mm. Rainfall poses risk and uncertainty in agricultural production for any season, especially in countries that practice rainfed agriculture, which is mainly developing countries like South Africa. A study by Amare *et al*. (2021) in Nigeria found that a negative rainfall shock strongly affects agricultural production negatively in which a negative rainfall shock reduces agricultural production by 38%. Furthermore, South Africa has warmer days than cooler days. Hence, rainfed agriculture is not reliable for most farmers and it is the reason why agricultural production is higher in irrigated areas than in rainfed places (Jaramillo *et al.,* 2020).

3.10.3 Consumer price index

According to Keynes' theory, the consumer price index is a short-run outcome of demand pressure within the economy (Shilongo, 2019). The consumer price index is one of the most well executed and researched statistical programs globally. The consumer price index is openly the most followed measure of inflation. According to Ribba (2022), the consumer price index as a measure of inflation controls how governments spend. When the consumer price index increases, the value of agricultural production also increases (Muhammad-Lawal and Atte, 2009). Olatunji *et al.* (2012) used the Granger causality method and descriptive statistics in analysing agricultural production inflation in Nigeria. According to the study, changes in agricultural production (changes in stocks) resulted from changes in inflation for the years 1970 to 2006. This implies that the consumer price index and agricultural production are related or dependent on one another.

3.10.4 Food import value

Food imports are gradually becoming significant due to their positive effect on economic growth (Lee and Liu, 2014). According to Khashei and Bijari (2012), forecasting the value of agricultural food commodities must be done accurately because the changes in the agricultural sector and policy reforms affect the value of agricultural imports. Moreover, since agricultural development is a global mandate, governments must ensure that unnecessary costs are not incurred with the increasing food imports to minimize import security risks (Adewuyi *et al*., 2021). Import security risks are risks associated with importing enough quantity of food at affordable prices and at the right time (Baranauskaite and Jureviciene, 2021). Agricultural production output has been fluctuating over the years and food imports in South Africa have been increasing exponentially (Greyling *et al.,* 2015). South Africa was the net exporter of agricultural products in the 1980s (Oluwatoba *et al*., 2015). But the effects of sanctions on imports from South Africa due to the apartheid regime, as well as the inability to maintain international competitiveness, have prevented the country from maintaining its status as a net exporter of agricultural products (Linderson, 2020).

3.10.5 Population

Dao (2012) analysed the effect of population on economic growth using a statistical model. The study was based on 43 developing countries for the period 1990 to 2008. The results showed that an increase in population slows economic growth. In addition, economists usually identify population growth as a driver of economic growth because an increase in the population entails an increase in the labour force (Olulu *et al*., 2014). The history of Northern America shows that as the population was increasing, agricultural production was also increasing (Leonard, 1989). According to Djoumes (2021), agricultural production in Africa is mainly increased by an increase in traditional factors such as labour, land, and livestock. Where an increase in labour comes from population growth.

3.11 Summary

This chapter has provided important information related to the study. First, the chapter defined key concepts and provided detailed information on the nature of agricultural production in South Africa. In addition, the chapter provided an overview of public spending on agriculture in South Africa. The chapter also explored two theories of public expenditure, namely Keynesian theory and Wagnerian theory. Moreover, the chapter provided details on how public expenditure ensures agricultural development. Another section focused on the variables that influence the value of agricultural production. Finally, the chapter provided a handful of studies of the national and international context. Most of the studies used the Vector Error Correction Model (VECM) in their empirical analysis. Most of the studies reviewed concerned agricultural production and agricultural productivity since the literature on the value of agricultural production is very limited both in the national and international context.

CHAPTER 4
RESEARCH METHODOLOGY

4.1 Introduction

This chapter provides an overview of the study area and the type of data used in this study. In addition, this chapter provides details on the research design and data collection. Finally, the chapter provides background information on all analysis techniques, diagnostic tests, and variance decomposition used in this study.

4.2 Study area

South Africa is in the southern part of Africa. South Africa is bordered by Namibia, Botswana, Zimbabwe, Mozambique, and Swaziland as shown in Figure 4.1. The agricultural sector is counted among the most important sectors in the country. The South African agricultural sector is known for producing sufficient products which form part of the exports. Hence agricultural output contributes significantly towards economic growth. In South Africa, the main manufacturing sectors are food processing and the production of textiles, metals, and chemicals (Mabin *et al.,* 2022).

Figure 4.1: South African map

Source: Infoplease (2021)

4.3 Data type

This study used publicly available South African time series data for the period 1983 to 2019. The data consist of 37 years of observation in the value of agricultural production, government expenditure in agriculture, annual average rainfall, consumer price index, food import value, and population. The data on the value of agricultural production was aggregated since the agricultural sector is divided into smallholder agriculture and commercial agriculture.

4.4 Data collection

The data were collected from the Food and Agricultural Organisation (FAO), South African Reserve Bank (SARB), the World Bank, and Quantec databases. This study used the value of agricultural production as the dependent variable. The independent variables used are government expenditure in agriculture, average annual rainfall, consumer price index, food import value, and population. Table 4.1 summarises all variables used for analysis in the study and their sources.

Table 4.1: Description and source of study variables

Variables	Indicator	Measurement	Source
VAP	Value of agricultural production	Million rand	Quantec
GEA	Government expenditure in agriculture	Million rand	SARB
AAP	Annual average rainfall	Millimetre	World Bank
CPI	Consumer price index	Annual%	World Bank
FIV	Food import value	Million rand	Quantec
PG	Population	Number	FAO

4.5 Analytical techniques

Econometric Views (EViews) 12 student version statistical tool was used to analyse the data. EViews is an econometric software package for use with time series, cross-sectional or longitudinal (panel) data. EViews is used to manage data, perform econometric and statistical analysis, create forecasts or model simulations, and produce high-quality graphics and charts for publication or inclusion in other applications (EViews, 2019).

In achieving all empirical results, the study used multiple econometric procedures. The Augmented Dicky-Fuller (ADF) method was the first technique in examining the stationarity of the selected variables as mandatory for time series data. The second procedure included examining the cointegration relationship between the variables through using the Johansen cointegration test. The third procedure determined the causality between government spending in agriculture and the value of agricultural production using the Granger causality test. The Vector autoregression (VAR) model was used in investigating the relationship among selected variables. For diagnostic purposes, the study used autocorrelation, stability test, heteroscedasticity test, and normality test. The study also used impulse response analysis and variance decomposition. The different techniques are elaborated in the sub-sections that follow.

4.5.1 Unit root testing

Unit root testing aims to test for the stationarity of time series data. Unit root testing is crucial for time series data since the results acquired with non-stationary time series can only be used for that certain period and cannot be used for predicting future values (Banda *et al*., 2014). This study used the Augmented Dickey-Fuller (1979) method to test for the existence or non-existence of unit roots in the variables that were used in this study, namely, government spending in agriculture, average annual rainfall, consumer price index, food import value, and population. According to Shafuda (2015), the Augmented Dickey-Fuller method tests for a unit root and ultimately control higher-order serial correlation in a time series.

The Augmented Dickey-Fuller test can be conducted using the following regression (Dickey and Fuller, 1979):

$$\Delta Y_t = \alpha + \beta_t + \vartheta Y_{t-1} + \sum_{i-1}^{k} \lambda\Delta \times Y_{t-1} + \mu_t \ldots \quad (1)$$

Where ΔY_t is the first difference of the series Y, μ_i is a stochastic error term, in which $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$. B_1 is a constant, t is the time, β and ϑ are parameters.

The unit root specification model for this study can be expressed as follows:

$$\Delta VAP = zVAP_{t-1} + \mu_i \ldots \quad (1.1)$$

$$\Delta GEA = zGEA_{t-1} + \mu_i \ldots \quad (1.2)$$

$$\Delta CPI = zCPI_{t-1} + \mu_i \ldots \quad (1.3)$$

$$\Delta AAR = zAAR_{t-1} + \mu_i \ldots \quad (1.4)$$

$$\Delta FIV = zFIV_{t-1} + \mu_i \ldots \quad (1.5)$$

$$\Delta PG = zPG_{t-1} + \mu_i \ldots \quad (1.6)$$

Where VAP denotes the value of agricultural production, GEA stands for Government expenditure in agriculture, CPI consumer price index, AAR annual average rainfall, FIV food import value, and PG population.

4.5.2 The choice of lag length for VAR

This section elaborates on the selection of the maximum lag that a model should be based on. There are different lag criteria in estimating the Vector autoregressive model. There is the sequential modified LR test statistic acceptable at a 5% level of significance. Other lag testing criteria include Final prediction error, Akaike information criterion, Schwarz information criterion, and Hannan-Quinn information criterion. The Schwarz information criterion and the Akaike information criterion are commonly used while the Hannan-Quinn information criterion is also used but not applicable in most cases.

Mathematical expressions of different lag selection criteria as stated by Mahlangu (2019) are as follows:

$E = \left(\frac{T+n^*}{T+n^*}\right)^{K'} + [\hat{\sum}\mu]$ ... ...(2)

$AIC = log[\hat{\sum}\mu] + 2\frac{K'}{T}$ ... ...(3)

$SIC = log[\hat{\sum}\mu] + \frac{K'}{T} log\ (T)$... ... ...(4)

$HQIC = log[\hat{\sum}\mu] + \frac{K'}{T} log\ (log(T))$ ... ...(5)

Where $\hat{\sum}\mu$ is the variance-covariance of the residual, n^* is the total number of parameters, K' is the total number of regressors in all equations, and T is the sample size.

4.5.3 Cointegration testing

The study used the Johansen test of cointegration to address the first objective of analysing the long-run and short-run relationship between government spending in agriculture and the value of agricultural production. A Johansen cointegration test is a vector autoregressive-based cointegration test (Johansen, 1988). Johansen proposes two different likelihood ratio tests which are named the trace test and the maximum eigenvalue test.

$J_{trace} = -T \sum_{i=r+1}^{n} \ln(1-\lambda_i)$... ... ...(6)

$zJ_{max} = -T \ln\ (1-\lambda_{r+1})$... ... ... (7)

Where T is the sample size, λ_i is the ith largest canonical correlation and r is the number of cointegrating vectors.

4.5.4 Causality testing

The Granger causality test was used to address objective 2 of determining the causality between government spending in agriculture and the value of agricultural production. The Granger causality test is used to test for causality between subsets of variables. Moreover, the Granger causality test establishes the direction of causality among the variables that are included in the system and establish the relevance of one variable in predicting future trends of other variables (Rasheed and Tahir, 2012). The general formula employed by Granger (1969) is given as:

$$X_i = \sum_{j=1}^{m} a_j X_{t-j} + \sum_{j=1}^{m} b_j Y_{t-j} + e_i \ldots \ldots (8)$$

$$Y_i = \sum_{j=1}^{m} c_j X_{t-j} + \sum_{j=1}^{m} b_j Y_{t-j} + n_i \ldots \ldots (9)$$

Where X_i and Y_i are variables included in the system. Equations 8 and 9 imply that X_i is granger causing Y_t when a_j is not zero. Additionally, Y_t granger causes X_i when c_j is not zero.

The null hypothesis for the bivariate equations 8 and 9 is that X_i does not granger cause Y_i in the first regression and Y_i does not granger cause X_i in the second regression for all pairs of (x, y) series according to (Granger and Newbold, 1974).

4.5.5 Vector autoregression technique

Vector autoregressive (VAR) is a model based on the statistical properties of available data. The VAR was chosen for this study for the idea of building each model according to all the endogenous variables of the system. VAR provides a consistent and credible approach to data description, structural inference, forecasting, and policy analysis. The model is typically used in forecasting interconnected time series systems (Gou, 2017).

A reduced standard form of a Vector autoregressive model is expressed as follows:

$$Y_t = \sum_{i=1}^{p} A_i Y_{t-1} BX_t + U_t \ldots \ldots (10)$$

Where t = 1, ..., T, Y_t denotes a k vector of endogenous variables and X_t represents a d vector of exogenous variables. A_i and B are the matrices of the coefficients to be estimated.

The Vector autoregressive model was used to achieve objective 3 of determining the relationship between the value of agricultural production and selected independent variables: government spending in agriculture (GEA), annual average rainfall (AAR), consumer price index (CPI), food import value (FIV), and population growth (PG). To achieve one outcome from multiple variables, the Vector autoregressive model is the most suitable technique (Endaylalu, 2019).

The specific model that was used for data analysis for this study is stated as follows:

$$VAP = F\ (GEA, CPI, AAR, FIV, PG) \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (10.1)$$

In equation 10.1 the value of agricultural production is expressed as the function of GEA, CPI, AAR, FIV, and PG. Therefore, it is necessary to transform equation 10.1 into a multiple linear regression model as follows:

$$VAP = \beta_0 + \beta_1\ GEA + \beta_2\ CPI + \beta_3\ AAR + \beta_4\ FIV + \beta_5\ PG + \mu \dots \dots \dots \dots \dots \dots \dots (10.2)$$

To make the relationship between the value of agricultural production and independent variables more linear and clearer, the log transformation is introduced to equation 10.2 and forms the new model as equation 10.3.

$$lnVAP = \beta_0 + \beta_1\ lnGEA + \beta_2\ lnCPI + \beta_3\ lnAAR + \beta_4\ lnFIV + \beta_5\ lnPG + \mu \dots .. (10.3)$$

Where:

VAP = Value of agricultural production

GSA = Government spending in agriculture

AAR= Average annual rainfall

CPI = Consumer price index

FIV = Food import value

PG= Population

4.6 Diagnostic tests

This study used diagnostic tests such as autocorrelation test, stability test, heteroscedasticity test, and normality test to check whether the residual of the series passes all of them. Diagnostic tests are used to make earlier predictions on whether the model-building process is valid or not. According to Safi and Al-Reqep (2014), diagnostic checking in time series model building is a significant stage.

4.6.1 Autocorrelation

Autocorrelation or serial correlation is the cross-correlation of a signal with itself at different points in time. According to Hamilton (1994), the most common problem when using time series data is autocorrelation which is characterised by correlated estimated residuals. Autocorrelation simply means the similarities among observations as a function of the time lag among them. This study used the Residual Portmanteau test for autocorrelations which is a model for Q-Statistics for testing serial correlation (Mahdi, 2016). The Portmanteau test for autocorrelations was initially introduced by Box and Pierce (1970). Although the test has undergone many transformations over the years, it is still the most used test for autocorrelation. When the Portmanteau test is employed in its simple form, it is the sample size multiplied by the sum of p-squared sample autocorrelations which can be compared to critical values of a chi-squared distribution ith certain degrees of freedom (Zhu *et al*., 2017).

The most common Portmanteau test formula based on the residual autocorrelation coefficient is provided as follows according to Peña and Rodríguez (2006):

$$\hat{r}_k = \frac{\sum_{t=k+1}^{n} \hat{\varepsilon}_t \hat{\varepsilon}_{t-k}}{\sum_{\neq 1}^{n} \hat{\varepsilon}_t^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

Where $\hat{\varepsilon}_1, \ldots\ldots \hat{\varepsilon}_t,$ are the residuals obtained after estimating the model in a sample of size n, and $\hat{r}_k$ is the residual autocorrelation coefficient.

4.6.2 Stability test

This study used the AR Roots graph to test for stability, in which the graph reports the inverse roots of the characteristic AR polynomial. A Vector autoregressive (VAR) model is concluded to be stable if all the roots lie inside the circle. The AR Roots also help in analysing the impulse response, if the VAR model is not stable then the results for the impulse response may not be valid. According to Milanzi (2012), the Autoregressive (AR) graph shows whether the system is stationary or not. The main aim for conducting a stability test is to establish whether a model is stable or not.

4.6.3 Heteroscedasticity

Heteroscedasticity refers to a situation in which the variance of the regression error term or disturbance term conditional on the independent variables is not constant, (Stock and Watson, 2012). This study used the heteroscedasticity test to establish whether there is an existence of heteroscedasticity problem in the residuals or not. In addition, the heteroscedasticity test was conducted on individual components and on joint basis for more reliable results. The test is subject to the null and alternative hypotheses as follows:

H_0: There is no heteroscedasticity

H_1: There is heteroscedasticity

The decision rule is that the null hypothesis is rejected when the p-value is less than the 0.05 level of significance.

4.6.4 Normality test

The normality test examines whether the residuals are normally distributed or not. This study used the VAR Residual Normality Tests, Cholesky (Lutkepohl) which produced three normality test results which are Skewness, Kurtosis, and Jarque-Bera to check whether the residuals are normally distributed or not. Skewness, Kurtosis, and Jarque-Bera coefficients are given as follows according to (Jarque and Bera, 1987)

$$Y1 = \frac{\mu_3}{(\sqrt{\mu_2})^3} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \text{(12)}$$

$$Y2 = \frac{\mu_4}{\mu_2^2} - 3 \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \text{(13)}$$

Where Y1 and Y2 are skewness and kurtosis coefficients respectively.

For a given data set of Y1, …. Yn, the estimates of μ_2, μ_3, and μ_4 are obtained from the sample moments, in which the jth sample moment is given as:

$$m_j = \frac{1}{n} \sum_{t=1}^{n} (Y_t - \bar{Y}) j.. \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots ..\text{(14)}$$

Estimates of Y1 and Y2 are then obtained as:

$$Y1 = \frac{m_3}{(\sqrt{m_2})^3} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \text{(12.1)}$$

$$Y2 = \frac{m_4}{m_2^2} - 3 \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots ..\text{(13.1)}$$

$$JB = \frac{N-K+1}{6} \left(Y1^2 \, \frac{1}{2} \, (Y2 - 3)^2 \right) \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \text{(15)}$$

Where JB is the Jarque-Bera coefficient, N is the number of observations, K is the number of predictor variables, Y1 is the skewness of the sample's distribution, and Y2 is the kurtosis of the sample's distribution.

The decision rule is that if the P-value of all the tests is less than 0.05 (5%) significance level, then the null hypothesis that the residuals are normally distributed should be rejected and the alternative hypothesis that states that residuals are not normally distributed should be accepted (Hossain, 2015).

4.7 Impulse response analysis

Impulse response analysis is usually conducted to determine and establish how dependent variables respond to a shock in the error term directed to one or several equations included in the VAR model. Impulse response analysis makes it easy to understand the estimated coefficients in the VAR model (Ronayne, 2011). According to Singla and Beag (2014), Granger causality tests usually fail to show recurring feedback from variables in the analysis, resulting in granger causality results being insufficient in research. As a result of the predicament, impulse response analysis is considered the most appropriate way of interpreting models while considering transmission patterns and causality (Killian, 2001). Impulse response functions are used in determining and tracking the reactions of a system's variables to impulses of the system's shock. This study employed the impulse response analysis to consider the period of variables after the exogenous shocks.

4.8 Variance decomposition

According to Brooks (2008), variance decompositions examine the VAR model characteristics differently and thus provide significant information about the relative significance of each random innovation in affecting the VAR variables. Variance decomposition establishes a proportion of dependent variable movements which are a result of their shocks and the shocks of other variables included in the VAR model (Gujarati, 2004). Variance decomposition gives a marginal technique in analysing the VAR system elements. Variance decompositions offer the length of variations in the response of variables associated with the shocks of other variables in the system. This study adopted variance decomposition to understand how much each variable contributes to other variables in the VAR system.

4.9 Summary

This chapter gave brief information on the study area. The chapter also gave information on the nature of data and where the data was sourced from. Selected variables that are used in this study include the value of agricultural production, government expenditure in agriculture, consumer price index, average annual rainfall, food import value, and population. These variables were selected because they are important in influencing the value of agricultural production.

This chapter also gave an overview of econometric techniques used in the analysis. The study used the Augmented Dickey-Fuller Test to test for unit root existence, Johansen cointegration to test for a long-run relationship among the variables, and Vector autoregressive model (VAR) to analyse the relationship among the variables. The VAR model was chosen because of its ability to treat all variables as dependent variables. Hence enabling the study to broaden the analysis to how selected variables are influenced by each other. This chapter also gave an overview of diagnostic tests that the study used. The study used autocorrelation tests, stability tests, heteroscedasticity, and normality tests. Additionally, the chapter included an explanation of impulse response analysis which the study used to check how each variable acts towards the shocks transmitted by other selected variables. Lastly, the chapter included variance decomposition which the study used to check the length of variations in the response of variables associated with the shocks of other variables.

The following chapter presents all the results obtained through using techniques that are mentioned in this chapter to fulfil the objectives of the study.

CHAPTER 5
RESULTS AND DISCUSSION

5.1 Introduction

Chapter 5 shows and describes the details of the research methodology through empirical results that were obtained using econometric procedures. This chapter shows and discusses results that were obtained in descriptive statistics; Augmented Dickey-Fuller test (ADF); Johansen cointegration test; Granger causality test; Vector autoregressive model (VAR); diagnostic tests which include autocorrelation, stability test, heteroscedasticity, and normality test. Furthermore, the chapter shows and discusses the results of the impulse response functions and variance decomposition.

5.2. Descriptive statistics

This study begins with analysing the descriptive statistics of all variables because it is crucial for any econometric analysis.

Table 5.1: Descriptive statistics of the time series data

	VAP (Million Rand)	**GEA** (Million Rand)	**AAR** (Millimetres)	**CPI** (Annual%)	**FIV** Million Rand	**PG** (number)
Mean	91391.64	8570.432	451.79	69.299	26823.08	45083.78
Median	52185.60	5190.00	435.70	63.314	10704.40	45571.27
Maximum	286095.9	22289.00	624.40	158.927	92203.90	58558.27
Minimum	7881.40	833.00	314.20	9.616	1073.90	30993.76
Std. Dev.	86601.48	7291.56	75.11	43.95	30449.67	8035092
Skewness	1.01	0.71	0.43	0.44	1.06	-0.086
Kurtosis	2.75	1.92	2.46	2.13	2.66	1.929
Jarque-Bera	6.47	4.91	1.61	2.39	7.17	1.811
Probability	0.039	0.085	0.445	0.302	0.027	0.404
Sum	3381491	317106	16716.50	2564.07	992453.9	1668100
Sum Sq. Dev.	2.70E+11	1.91E+09	203113.7	69550.24	3.34E+10	2.32E+02
Observations	37	37	37	37	37	37
Where VAP is the value of agricultural production, GEA is government expenditure in agriculture, AAR is annual average rainfall, CPI is a consumer price index, FIV is food import value and PG is population.						

Source: Own computation (2021)

Table 5.1 shows detailed information regarding the time series data that was used to generate all the results in this study. The information that is included in Table 5.1 includes mean, median, maximum, minimum, standard deviation, skewness, kurtosis, Jarque-Bera, probability, sum, the sum of squared deviation, and the number of observations. Table 5.1 shows that the maximum VAP in the data set was R286095.9 and the minimum was R7881.48. Additionally, the average VAP was R52185.60. The maximum GEA was R22289.00, while the minimum was R833.00, and the average GEA was R8570.432. The maximum annual rainfall was 624.40 mil, while the minimum was 314.20 mil, and the average was 415.79 mil. CPI had a maximum of 158.927, while the minimum was 9.616 and an average of 69.299. FIV had a maximum of R92203.90, while the minimum was R1073.90 and the average were R26823.08. The maximum PG was 58558.27, while the minimum population was 30993.76, and the average population was 45083.78.

5.3. Unit root results

Usually, time-series data is characterised by a stochastic trend which can be removed by differencing the data. Unit root tests determine whether time series data is stationary or non-stationary and the results of the analysis are presented in Figure 5.1.

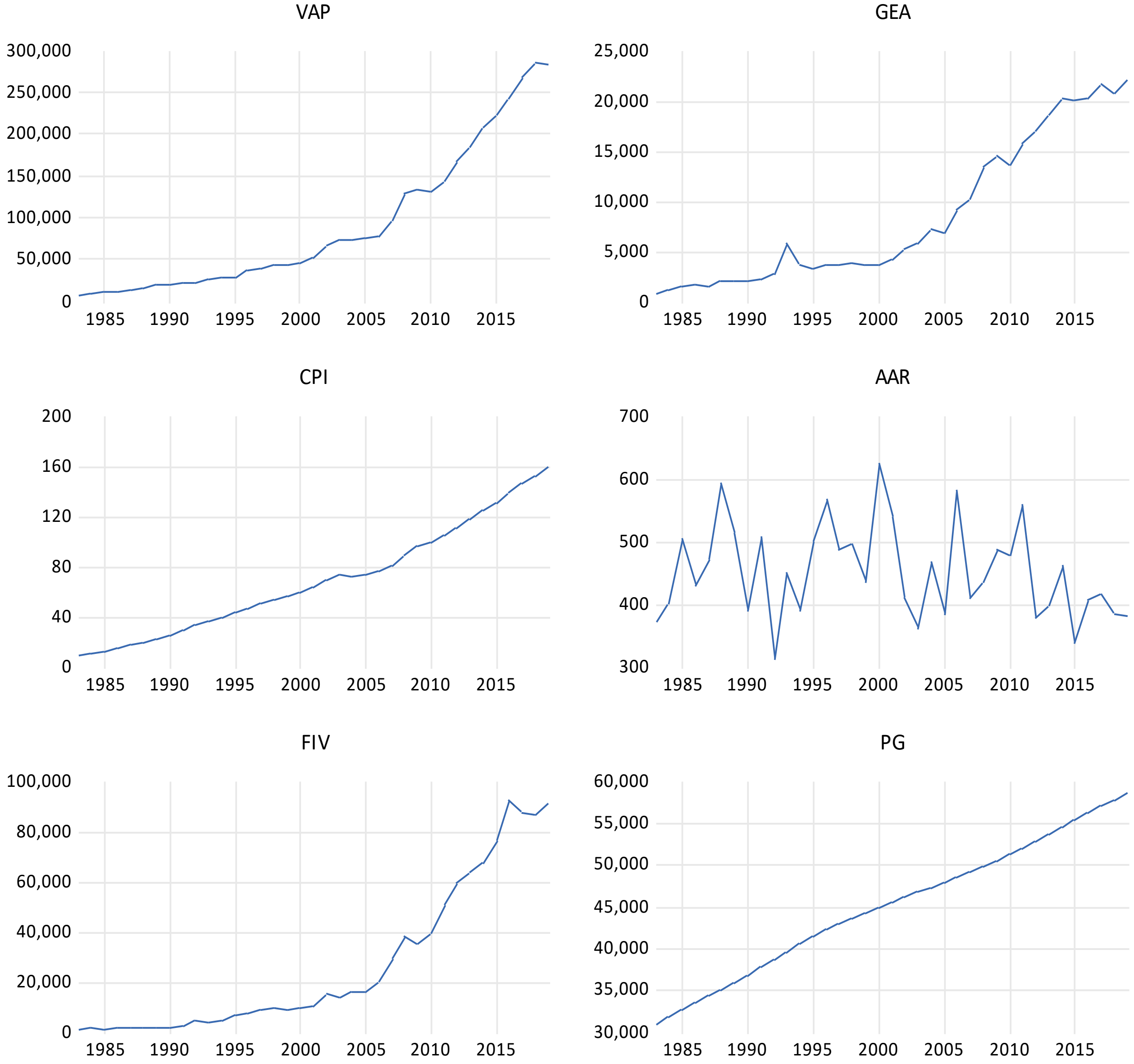

Figure 5.1: Graphical illustrations of variables in levels for the period of 1983 to 2019

Source: Own computation (2021)

According to figure 5.1, The value of agricultural production (VAP), Government expenditure in agriculture (GEA), Consumer price index (CPI), Food import value (FIV), and Population (PG) portray a growing trend throughout 1983 to 2019. While Average annual rainfall (AAR) has a fluctuating trend, the data for average annual rainfall (AAR) fluctuates whereas in other years the average rainfall increases then suddenly decrease in the following year. The data for the value of agricultural production (VAP), Government expenditure in agriculture (GEA), Consumer price index (CPI), Food import value (FIV), and Population (PG) has a trending nature showing that the time series must be differenced for it to be stationary.

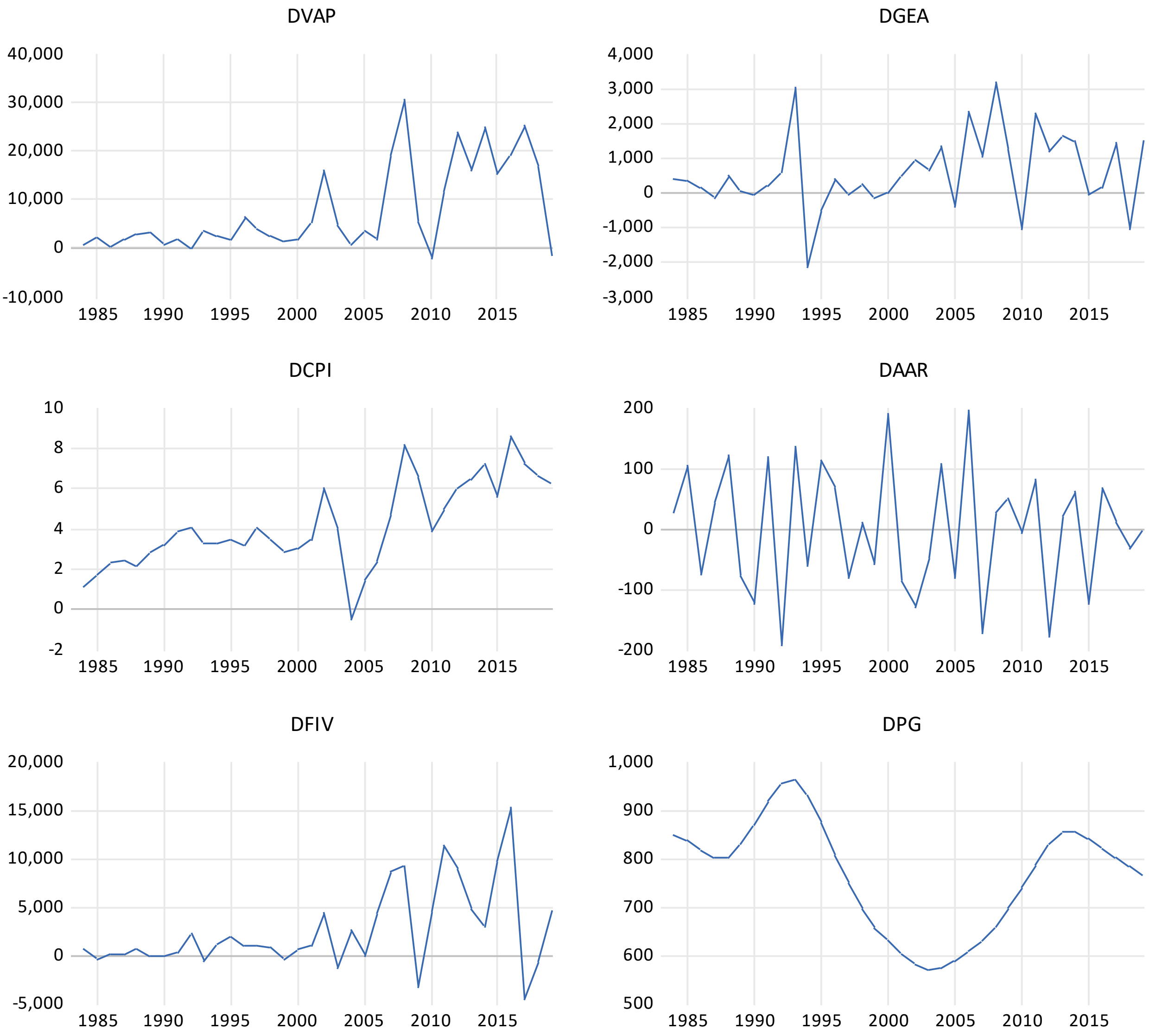

Figure 5.2: Graphical illustrations of variables in first difference for a period of 1983 to 2019

Source: Own computation (2021)

Figure 5.2 illustrates the first difference form of the value of agricultural production (VAP), Government expenditure in agriculture (GEA), Consumer price index (CPI), Average annual rainfall (AAR), Food import value (FIV), and Population (PG). Figure 5.2 is different from figure 5.1 in a manner that figure 5.2 shows the stationarity of all the selected variables. The time-series data is integrated of order I(1) to ensure stationarity and to avoid spurious regression. For more reliability, a formal test using the Augmented Dickey-Fuller test was conducted and results presented in Table 5.2:

Table 5.2: Augmented Dickey-Fuller test results for stationarity

Variables	Formula	ADF			
		Levels	**5% critical value**	**1st difference**	**5% critical value**
VAP	Intercept	-3.111**	-2.951	-2.222	-2.976
	Trend and intercept	-0.706	-3.587	-0.898	-3.587
	None	3.760**	1.951	3.169**	-1.593
GEA	Intercept	0.969	-2.945	-6.393**	2.948
	Trend and intercept	-1.434	3.540-	-6.881**	-3.544
	none	3.057**	-1.950	-0.852	-1.952
AAR	Intercept	-5.507**	-2.945	-4.554**	-2.957
	Trend and intercept	-5.777**	-3.540	-4.326**	-3.595
	None	-0.477	-1.951	-4.616**	-1.951
CPI	Intercept	3.069**	-2.951	-2.472	-2.948
	Trend and intercept	-0.754	-3.548	-4.034**	-3.548
	None	-2.817**	-1.951	1.080	-1.952
FIV	Intercept	-1.749	-2.971	-1.271	-2.957
	Trend and intercept	-2.427	-3.580	-5.892**	-3.548
	None	-1.575	-1.952	-0.474	-1.951
PG	Intercept	-1.030	-2.957	-3.277**	-2.967
	Trend and intercept	-6.878**	-3.552	-2.651	-3.557
	None	1.409	-1.951	-0.518	-1.951

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

Source: Own computation (2021)

Table 5.2 shows the results acquired through the Augmented Dickey-Fuller test. The results show that the value of agricultural production (VAP), Government expenditure in agriculture (GEA), Consumer price index (CPI), Average annual rainfall (AAR), and Population (PG) were stationary at levels on either intercept, trend, and intercept, or none. However, the Food import value (FIV) was not stationary at levels on all equations. The variables were differenced at levels to reject the null hypothesis that states that there is a unit root existing in the time series data. After differencing, all the variables were found to be stationary. Therefore, the variables are integrated of order I(1), and the null hypothesis of unit root existence is rejected.

5.4 Lag order selection criteria

Lag order selection is an important step in model building. This study used the information criteria approach to select the correct lag. Lag selection in this study is important in cointegration analysis, estimation of the Vector autoregressive model (VAR), Granger causality test, and an impulse response analysis.

Table 5.3: Lag order selection criteria

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-2019.344	NA	7.38e+42	115.7340	116.0006	115.8260
1	-1794.744	359.3606	1.59e+38	104.9568	106.8232	105.6011
2	-1739.838	69.02402*	6.54e+37*	103.8765*	107.3427	105.0730*

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

Source: Own computation (2021)

The results in Table 5.3 show that lag length 2 is suggested by 4 criteria which are LR, FPE, AIC, and HQ. The choice of lag length can affect the results of cointegration and VAR, hence in this case it was convenient to choose the most optimal lag order which is 2.

5.5 Johansen cointegration results

Since the Augmented Dickey-Fuller test (ADF) showed stationarity of selected variables, it is important to determine the long-run relationship that exists among the variables. In this study, the Johansen cointegration test was conducted to obtain the long-run relationship results. The Johansen cointegration test provides the number of cointegrating equations. Furthermore, this study adopted the two tests namely the Trace test and the Maximum eigenvalue test. This study determines the long-run relationship between the value of agricultural production and other selected variables, then separately between the value of agricultural production and government expenditure alone.

Table 5.4: Johansen cointegration test results (All variables included)

		Trace test		**Maximum eigenvalue test**	
Hypothesised no. of CE(s)	Eigenvalue	Trace statistics	0.05 critical value	Maximum eigenvalue statistics	0.05 critical value
None*	0938	192.076**	95.753	55.004**	40.077
At most 1*	0.708	97.072**	69.818	41.966**	33.876
At most 2*	0.551	55.106**	47.856	27.268	27.584
At most 3	0.424	27.838	29.797	18.807	21.131
At most 4	0.226	9.030	15.494	8.711	14.264
At most 5	0.009	0.319	3.841	0.319	3.841
Trace test indicates 3 cointegrating eqn(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					

Source: Own computation (2021)

Table 5.4 illustrates the results of the Johansen cointegration test when all the variables are included. From the trace test, there are three cointegrating equations at a 5% level of significance. From the maximum eigenvalue test, there are 2 cointegrating equations at a 5% level of significance. The rule of thumb states that the null hypothesis is rejected when there is no cointegration among the variables. Therefore, the null hypothesis of no cointegrating equations for the trace test is rejected at none because the trace statistic is 192.076 which is greater than the critical value of 95.004 at a 5% level of significance. Additionally, the null hypothesis is also rejected for the trace test at (at most 1) because the trace statistic is 97.072 which is greater than the critical value of 69.818 at a 5% significance level. Moreover, the null hypothesis is rejected at (at most 2) since the trace statistic is 55.106 which is greater than the critical value of 47.856. Therefore, based on the trace test it is concluded that there are cointegrating equations confirming that there is a long-run relationship that exists between the variables.

The maximum eigenvalue test shows Maximum eigenvalue statistics of 55.004 at (none), which is greater than the critical value of 40.077. There is a cointegrating equation at none based on these findings. In addition, the maximum eigenvalue test shows a maximum eigenvalue statistic of 41.996 at (at most 1) which is greater than the critical value of 33.876 at a 5% level of significance. Therefore, there is a cointegrating equation at (at most 1). The null hypothesis that there is no cointegration is rejected based on the maximum eigenvalue test, confirming that there is a long-run relationship between the variables.

Table 5.5: Johansen Cointegration test results for VAP and GEA only

		Trace test		**Maximum eigenvalue test**	
Hypothesised no. of CE(s)	Eigenvalue	Trace statistics	0.05 critical value	Maximum eigenvalue statistics	0.05 critical value
None*	0.465245	21.614**	15.494	21.282**	14.284
At most 1	0.009735	0.332	3.841	0.332	3.841
Trace test indicates 1 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					

Source: Own computation (2021)

Table 5.5 shows the Johansen cointegration test results for the value of agricultural production and government spending in agriculture. Based on the trace test, there is a cointegrating equation at (none) because the trace statistic of 21.614 is greater than the critical value of 15.494. Therefore, the null hypothesis that there is no cointegration is rejected based on the trace test. Additionally, the null hypothesis that there is no cointegration is rejected based on the maximum eigenvalue test because the maximum eigenvalue statistic is 21.282 at (none), which is greater than the critical value of 14.284. Therefore, it is concluded that there is a long-run relationship between the value of agricultural production and government expenditure in agriculture in South Africa (The nature of this relationship is explained in subsection 5.7.2.2). These findings are in line with the findings of Chandio *et al.* (2016) who analysed the impact of government expenditure on the agricultural sector and economic growth in Pakistan. Chandio *et al.* (2016) used the Johansen cointegration test to check for the long-run relationship between government expenditure in agriculture and agricultural production output. The results of Chandio *et al.* (2016) confirmed that there is a long-run relationship that exists between government expenditure in agriculture and agricultural production output based on both the trace test and the maximum eigenvalue test. Additionally, these results concur with the findings of Umair *et al.* (2017) who analysed government expenditure and some representative agricultural product prices and their impact on the agricultural growth of Pakistan. Umair *et al.* (2017) used an Autoregressive Distributed Lag (ARDL) model and established that there is a long-run relationship that exists between government expenditure in agriculture and agricultural economic growth and the relationship is manifested through the prices of agricultural products.

5.6 Granger causality results

The Johansen cointegration test proved that there is cointegration between the value of agricultural production and other selected variables. This section checks the causality using the Granger causality test. The Granger causality test gives results of the causal association among selected variables, and it gives the directional causality between two variables. Table 5.6 shows the causal association between the value of agricultural production and all selected variables based on the probability values.

Table 5.6: Granger Causality results

Null Hypothesis	Obs.	F-Stat.	Prob.	Decision
DGEA does not Granger cause DVAP DVAP does not Granger cause DGEA	34 included	0.24541 1.59284	0.7840 0.2206	Accept Accept
DCPI does not Granger cause DVAP DVAP does not Granger cause DCPI	34 included	0.39003 2.08565	0.6805 0.1425	Accept Accept
DAAR does not granger cause DVAP DVAP does not Granger cause DAAR	34 included	0.42173 2.13975	0.6599 0.1359	Accept Accept
DFIV does not Granger cause DVAP DVAP does not Granger cause DFIV	34 included	9.92527 1.46711	0.0005** 0.2472	Reject Accept
DPG does not Granger cause DVAP DVAP does not Granger cause DPG	34 included	0.54354 0.29980	0.5865 0.7432	Accept Accept
Notes: Granger cause if P < 0.05 * Statistically significant at 1% level ** Statistically significant at 5% level *** Statistically significant at 10% level				

Source: Own computation (2021)

The results shows that government expenditure in agriculture does not granger cause the value of agricultural production. These results are in line with the results of Oinam *et al.* (2022) who analysed the impact of public expenditure on agricultural growth in India. Oinam *et al.* (2020) used a Pairwise Granger causality test and concluded that government expenditure in agriculture in India does not granger cause agricultural GDP because government expenditure is not optimally allocated in the agricultural sector. In South Africa, government expenditure in agriculture is still poorly allocated (Aguera *et al.,* 2020) and would therefore not stimulate substantial increases in agricultural output. Which is the possible reason why government expenditure in agriculture does not granger cause the value of agricultural production just like in India, contemplating that poor governance in resource allocation can lead to failure in addressing economic objectives such as the objectives of the fiscal policy (Nguyeng and Luong, 2021).

These results do not concur with the study of Mile *et al.* (2021) which made an empirical analysis of government agricultural spending and agricultural output value in

Nigeria. The study of Mile *et al.* (2021) used the Vector Error Correction Granger Causality/Block homogeneity Wald test and found that government agricultural spending granger causes gross agricultural output value because Nigeria allocates 5% of its total government expenditure to the agricultural sector. Unlike in South Africa where the government only allocate 1% of its total government expenditure to the agricultural sector as stated in the introduction chapter. Therefore, both Oinman *et al*. (2022) and Mile *et al*. (2021) give emphasis on the reasons why government expenditure in agriculture does not granger cause the value of agricultural production in South Africa. These results imply that government expenditure in agriculture alone is not useful in forecasting future values of the value of agricultural production. However, it does not mean that there is no relationship between the value of agricultural production and government expenditure in agriculture (The Johansen Cointegration test results established a long-run relationship existence between the two variables).

Additionally, the study findings show that the value of agricultural production does not granger cause government expenditure in agriculture. These findings are in line with the study of Bassey and Amaraihu (2018) which was conducted in Nigeria titled agricultural expenditure, Maputo declaration target and agricultural output: A case study of Nigeria. Bassey and Amaraihu (2018) used a Pairwise Granger Causality test to check the causality between actual agricultural expenditure and agricultural output and established that agricultural output in Nigeria does not granger cause government expenditure in agriculture. Even though the Johansen cointegration test proved that there is a long-run relationship between the value of agricultural production and government expenditure in agriculture, the Granger causality test proved that there is no causality between the two variables. Hence these findings prove that Wagner's theory does not hold for the agricultural sector in South Africa because Wagner (1876) as defined in the literature review chapter states that the causality between economic growth and government expenditure runs from economic growth to government expenditure and not vice versa.

In other results, the only variable that granger causes the value of agricultural production from all selected variables is food import value. The generated probability from the Granger causality test is 0.0005 which is less than the 5% level of significance. Therefore, implying that food import value granger causes the value of agricultural production in South Africa. These results shows that food import value is crucial in forecasting future values of the value of agricultural production (a further discussion of this relationship is elaborated in 5.7.1.1). These results are not in line with the study of Syed (2015) which analysed the impact of agricultural imports and exports on agricultural productivity in Pakistan. Syed (2015) used the pairwise granger causality test to check for causal association between food imports and agricultural productivity, the study found that food imports do not granger cause agricultural productivity in Pakistan.

5.7 Vector autoregressive model results

A Vector autoregressive (VAR) is an n-equation, n-variable model that is linear. In a VAR model, each variable is explained by its own lagged values and past or current values of the other included n-1 variables. Table 5.7 presents the results of the VAR model.

Table 5.7: Vector Autoregressive model results

	lnVAP	**lnGEA**	**lnCPI**	**lnAAR**	**lnFIV**	**lnPG**
lnVAP (-1)	0.638779	-0.267	0.061	-0.889	-0.167	0.002
	(0.211)	(0.560)	(0.048)	(0.520)	(0.5480)	(0.001)
	[3.017]**	[-0.477]	[1.280]	[-1.710]	[-1.710]	[1.895]
lnVAP (-2)	-0.073	0.576	-0.064	0.332	-0.282	0.004
	(0.167)	(0.443)	(0.038)	(0.412)	(0.434)	(0.001)
	[-0.435]	[1.297]	[-1.694]	[0.807]	[-0.649]	**[3.414] ****
lnGEA (-1)	0.161	0.748	0.031	-0.360	0.194	-0.001
	(0.077)	(0.205)	(0.017)	(0.191)	(0.201)	(0.000)
	[2.082]**	**[3.639]****	[1.757]	[-1.887]	[0.963]	**[3.166] ****
lnGEA (-2)	-0.033	-0.137	-0.014	0.498	0.297	-0.000
	(0.069)	(0.183)	(0.015)	(0.170)	(0.179)	(0.000)
	[-0.488]	[-0.750]	[-0.886]	**[2.927]****	[1.653]	[-1.487]
lnCPI (-1)	-0.208	1.150	0.988	0.478	-0.119	-0.003
	(0.617)	(1.633)	(0.140)	(1.516)	(1.600)	(0.004)
	[-0.337]	[0.704]	**[7.013]****	[0.315]	[-0.074]	[-0.733]
lnCPI (-2)	-0.564	-1.589	-0.273	0.165	-0.859	-0.004

	(0.625)	(1.654)	(0.142)	(1.536)	(1.620)	(0.004)
	[-0.903]	[-0.960]	[-1.919]	[0.107]	[-0.530]	[1.024]
lnAAR (-1)	0.088	-0.235	0.033	-0.119	0.229	0.000
	(0.066)	(0.174)	(0.015)	(0.162)	(0.171)	(0.000)
	[1.346]	[-1.351]	**[2.226]****	[-0.739]	[1.340]	[1.246]
lnAAR (-2)	0.120	0.083	0.059	-0.108	0.007	0.001
	(0.073)	(0.193)	(0.016)	(0.180)	(0.189)	(0.000)
	[1.639]	[0.431]	**[3.561]****	[-0.601]	[0.041]	**[2.209] ****
lnFIV (-1)	0.146	0.481	-0.023	0.252	0.354	-0.000
	(0.070)	(0.185)	(0.015)	(0.172)	(0.181)	(0.000)
	[2.097]**	**[2.601]****	[-1.478]	[1.465]	[1.952]	[-0.441]
lnFIV (-2)	-0.234	-0.517	-0.043	0.318	-0.199	-0.002
	(0.076)	(0.202)	(0.017)	(0.188)	(0.198)	(0.000)
	[-3.066]**	**[-2.558]****	**[-2.502]****	[1.695]	[-1.006]	**[-3.735]****
lnPG (-1)	4.397	-6.393	5.838	-35.667	11.595	1.822
	(6.377)	(16.871)	(1.455)	(15.671)	(16.531)	(0.046)
	[0.689]	[-0.378]	**[4.010]****	**[-2.275]****	[0.701]	**[38.903]****
lnPG (-2)	1.527	8.699	-4.175	29.769	-0.373	-0.860
	(5.951)	(15.745)	(1.358)	(14.625)	(15.428)	(0.043)
	[0.256]	[0.552]	**[-3.073]****	**[2.035]****	[-0.024]	-19.683
C	-57.095	-21.567	-16.738	68.242	-109.044	-0.325
	(17.904)	(47.368)	(4.087)	(43.999)	(46.414)	(0.131)
	[-3.188]	[-0.455]	[-4.095]	[1.550]	[-2.349]	[2.473]
R squared	0.997	0.982	0.999	0.548	0.992	0.999
Adj. R squared	0.996	0.972	0.999	0.302	0.988	0.999
Sum aq. Resids	0.069	0.485	0.003	0.419	0.466	3.75E-06
S.E equation	0.056	0.148	0.012	0.138	0.145	0.000
F.statistic	906.805	101.016	8613.787	2.228	252.859	473379.8

Log-likelihood	59.246	25.195	110.949	27.777	25.907	231.213
Akaike AIC	-2.642	-0.696	-5.597	-0.844	-0.737	-12.469
Schwarz	-2.064	-0.119	-5.019	-0.266	-0.159	-11.891
Mean dependent	11.029	8.743	4.077	6.108	9.495	10.719
No parentheses, (.), [.] represents the coefficient, standard error, and t-stat respectively. ** represents statistical significance at 95%						

Source: Own computation (2021)

5.7.1 Discussion summary of study findings presented in Table 5.7

5.7.1.1 Government expenditure in agriculture

The results in Table 5.7 show that there is a significant positive relationship between the one-year lagged government expenditure in agriculture and government expenditure in agriculture. A 1% increase in a one-year lagged government expenditure increases government expenditure in agriculture by 74.8%. The findings are in line with the study of Okpara (2017) which analysed the effect of government expenditure on agriculture and agricultural output on the Nigerian economic growth for the period 1980 to 2015. The study found that government expenditure on agriculture has a positive relationship with government expenditure on agriculture. Additionally, the results show that there is a positive significant relationship between a one-year lagged food import value and government expenditure in agriculture where a 1% increase in food import value increases government expenditure in agriculture by 48%. However, the results also show that there is a negative relationship between a two-year lagged food import value and government expenditure in agriculture where a 1% increase in food import value on a two-year lagged basis reduces government expenditure in agriculture by 51.7%.

5.7.1.2 Consumer Price Index

The results show that there is a positive significant relationship between a one-year lagged consumer price index and the consumer price index. When the consumer price index increases by 1%, the consumer price index increases by 98.8%. Additionally, the results in Table 5.7 show that there is a positive significant relationship between a one-year lagged average annual rainfall and the consumer price index where a 1% increase in average annual rainfall increases consumer price index by 3.3%. Moreover, the results show that there is a positive significant relationship between a two-year lagged average annual rainfall and the consumer price index where a 1% increase in average annual rainfall increases the consumer price index by 5.9%. These findings are in line with the findings of Octoviani *et al.* (2011) which were based on the impact of global climate change on the Indonesian economy, the findings revealed that a decrease in rainfall reduces agricultural production. Furthermore, the findings state that when production is low the prices of agricultural goods are likely to be high which pushes the consumer price index to be high.

5.7.1.3 Average Annual rainfall

The findings also show that there is a positive significant relationship between a two-year lagged government expenditure in agriculture and average annual rainfall, whereby an increase in government expenditure in agriculture increases average annual rainfall. The relationship between government expenditure and rainfall might not be direct. Leppanen *et al.* (2015) analysed the impact of climate change on regional government expenditures in Russia. From the evidence that Leppanen *et al.* (2015) gathered, a decline in rainfall results from a decrease in government expenditure but the relationship between government expenditure and rainfall is not linear. Jin *et al*. (2021) assessed how government expenditure mitigates emissions that reduce rainfall. Jin *et al.* (2021) found that spending on research and development influences the cuts in carbon dioxide levels in both industrialised and emerging economies. Carbon dioxide emissions and rainfall have a negative correlation as stipulated in a study on variations in atmospheric carbon dioxide and its association with rainfall and vegetation over India by Tiwari *et al*. (2013). Therefore, carbon dioxide concentration is reduced when the government spends on agricultural research and development which indirectly leads to improved rainfall patterns.

Table 5.7 showed the Vector autoregressive model results for all the data series included in the study. For this study, the area of interest was to focus on the first column which showed the lagged independent variables, and the second column which showed the relationship between independent variables with the value of agricultural production (lnVAP). However, relying on Table 5.7 alone to emphasize the relationship between the value of agricultural production and selected independent variables was not efficient because the results lack probability values. Therefore, the next step was to generate probability values and sample out the area of focus for this study as shown in Table 5.8. Table 5.8 shows the outsourced VAR model results which are the results that emphasize the relationship between the value of agricultural production and selected independent variables.

Table 5.8: Outsourced Vector Autoregression model results

lnVAP as the dependent variable				
Independent variables	**Coefficient**	**Std. Error**	**t-stat**	**Prob.**
lnVAP(-1)	0.638779	0.211706	3.017297	0.0031**
lnVAP(-2)	-0.073059	0.167798	-0.435402	0.6640
lnGEA(-1)	0.161955	0.077764	2.082641	0.0392**
lnGEA(-2)	-0.033866	0.069297	-0.488704	0.6259
lnCPI(-1)	-0.208038	0.617256	-0.337037	0.7366
lnCPI(-2)	-0.564957	0.625236	-0.903591	0.3679
lnAAR(-1)	0.088903	0.066007	1.346888	0.1803
lnAAR(-2)	0.120143	0.073278	1.639548	0.1035
lnFIV(-1)	0.146890	0.070018	2.097902	0.0378**
lnFIV(-2)	-0.234572	0.076503	-3.066171	0.0026**
lnPG(-1)	4.397032	6.377028	0.689511	0.4917
lnPG(-2)	1.527991	5.951629	0.256735	0.7978
C	-57.09542	17.90459	-3.188870	0.0018
Observations: 35				
R-squared	0.997982	Mean dependent var	11.02903	
Adjusted R-squared	0.996882	S.D. dependent var	1.005709	
S.E. of regression	0.056160	Sum squared resid.	0.069386	
Durbin-Watson stat	2.418308			

Source: Own computation (2021)

5.7.2 Discussion of statistically significant study findings presented in Table 5.8

Table 5.8 shows the results of the VAR model where the value of agricultural production is the dependent variable. The adjusted R-squared is 99.68% showing that the variation in the value of agricultural production is explained by the included independent variables. The model has no autocorrelation since the Durbin-Watson statistic is 2.41.

5.7.2.1 Value of agricultural production

There is a positive statistically significant relationship between the value of agricultural production and the one-year lagged value of agricultural production. The coefficient of the one-year lagged value of agricultural production is 0.638. Implying that a 1% increase in the value of agricultural production increases the country's value of agricultural production by 63.87% in the current year. The results are consistent with the findings of Iganiga and Unemhilin (2011) who analysed the impact of government agricultural expenditure on the value of agricultural output in Nigeria. Iganiga and Unemhilin (2011) concluded that the value of agricultural output increases the value of agricultural output on the first lag. Additionally, the relationship between the value of agricultural production and the two-year lagged value of agricultural production is negative and statistically insignificant. The coefficient of the two-year lagged value of agricultural production is-0.073. Implying that a 1% increase in the value of agricultural production reduces the value of agricultural production by 7.30% in the second year.

5.7.2.2 Government expenditure in agriculture

The findings also show a significant positive relationship between the value of agricultural production and the one-year lagged government expenditure in agriculture. A 1% increase in government expenditure in agriculture increases the value of agricultural production by 16.19% in the current year. Implying that increasing government expenditure in agriculture is good for the value of agricultural production. The results are consistent with the study of Ebenezer *et al*. (2019) who analysed the impact of government expenditure in South Africa. Ebenezer *et al.* (2019) concluded that there is a positive long-run relationship between government expenditure in agriculture and agricultural productivity. A negative insignificant relationship between the value of agricultural production and a two-year lagged government expenditure in agriculture was also found. Where a 1% increase in government expenditure in agriculture results in a 3.33% decrease in the value of agricultural production. These findings concur with the findings of Selvaraj (1993) who analysed the impact of government expenditure on agriculture and the performance of the agricultural sector in India. Selvaraj (1993) found that government expenditure in agriculture due to its instability is detrimental to agricultural growth in India. These results imply that government expenditure in agriculture increases the value of agricultural in the short-run and negatively affects the value of agricultural production in the long run, entailing the problem of diminishing marginal productivity of government expenditure in the agricultural sector (IMF, 2022).

5.7.2.3 Food import value

There is a positive significant relationship between one-year lagged food import value and the value of agricultural production. A 1% increase in food import value increases the value of agricultural production by 14.68% in the current year. Additionally, the results show that there is a negative significant relationship between the two-year lagged food import value and the value of agricultural production. Where a 1% increase in food import value decreases the value of agricultural production by 23.45%. These findings concur with the findings of Iganiga and Unemhilin (2011) who analysed the impact of government agricultural expenditure on the value of agricultural output in Nigeria. The study of Iganiga and Unemhilin (2011) found that a two-year lagged food import value reduces the value of agricultural production in Nigeria. These results imply that importing food from other countries positively benefits the local agricultural sector in the short-run. However, importing food reduces local food production in the long-run

5.7.3 Discussion of statistically insignificant study findings presented in Table 5.8

5.7.3.1 Consumer Price Index

There is a negative insignificant relationship between the value of agricultural production and a one-year lagged consumer price index. When a one-year lagged consumer price index increases by 1%, the South African value of agricultural production declines by 20.8%. Additionally, Table 5.8 shows that there is a negative insignificant relationship between a two-year lagged consumer price index and the value of agricultural production. Whereby a 1% increase of a two-year lagged consumer price index reduces the value of agricultural production by 56.49%. The results are in line with the findings of Gou (2017) who analysed the relationship between agricultural product price fluctuation and consumer price index in China. Gou (2017) concluded that an increase in the consumer price index reduces agricultural product prices. Agricultural product prices can be considered as the value of agricultural production.

5.7.3.2 Annual Average rainfall

The results show that there is a positive insignificant relationship between a one-year lagged annual average rainfall and the value of agricultural production. In which a 1% increase in a one-year lagged annual average rainfall leads to an 8.89% increment of the value of agricultural production. Moreover, there is a positive insignificant relationship between a two-year lagged annual average rainfall and the value of agricultural production. A 1% increase in annual average rainfall increases the value of agricultural production by 12.01%. The results are in line with the results of Akinniran *et al*. (2013) who analysed the effect of rainfall variability on crops production in Oyo State, Nigeria. The study of Akinniran *et al.* (2013) concluded that an increase in rainfall increases agricultural production. An increase in agricultural production subsequently increases the value of agricultural production that this study is focusing on.

5.7.3.3 Population

The results in Table 5.8 show that there is a positive insignificant relationship between a one-year lagged population and the value of agricultural production. A 1% increase in a one-year lagged population increases the value of agricultural production by 4.39%. Additionally, the results show that there is a positive insignificant relationship between a two-year lagged population and the value of agricultural production whereby a 1% increase in population increases the value of agricultural production by 1.52%. These results are in line with the record of Boserup (1965) which highlighted that population increases agricultural output. Moreover, the results are consistent with the study of Schneider *et al.* (2021) which focused on the impacts of population growth, economic development, and technical change on global food production and consumption. Schneider *et al.* (2021) found that population increases global food production.

5.8 Diagnostic test results

This study used diagnostic tests such as autocorrelation test, stability test, heteroscedasticity test, and normality test to check if the model is correctly specified. The VAR model is correctly specified when it passes all the diagnostic tests that are presented in this sub-section.

5.8.1 Autocorrelation

The diagnostic portmanteau test for autocorrelation was introduced by Box and Pierce (1970) based on the asymptotic distribution of the residual autocorrelations. This study used the Residual Portmanteau test for autocorrelation as stated in the methodology chapter. The results of the Residual Portmanteau test are presented in Table 5.9.

Table 5.9: Residual Portmanteau test for autocorrelations

Lags	**Q-stat**	**Prob.**	**Adj. Q-Stat**	**Prob**
1	32.41422	0.6399	33.36758	0.5944
2	67.28969	0.6352	70.35672	0.5328
3	99.21200	0.7154	105.2717	0.5564
4	141.1634	0.5513	152.6362	0.2952
5	165.2629	0.7774	180.7523	0.4702
6	201.9447	0.7451	225.0234	0.3227
7	219.0135	0.9343	246.3594	0.5884
8	242.5161	0.9760	276.8258	0.6714
9	258.8741	0.9886	312.3077	0.6696
10	298.2603	0.9923	353.4484	0.6874
11	317.0195	0.9986	380.8055	0.6996
12	348.1986	0.9988	428.2483	0.5419

Source: Own Computation (2021)

The results suggest that there is no autocorrelation problem since the p-values of the Q statistics and adjusted Q statistics are greater than the 0.05 level of significance, the test was made at a 5% level of significance. Furthermore, the results suggest that the first order of the VAR is significant up to the 12^{th} lag.

5.8.2 Stability test

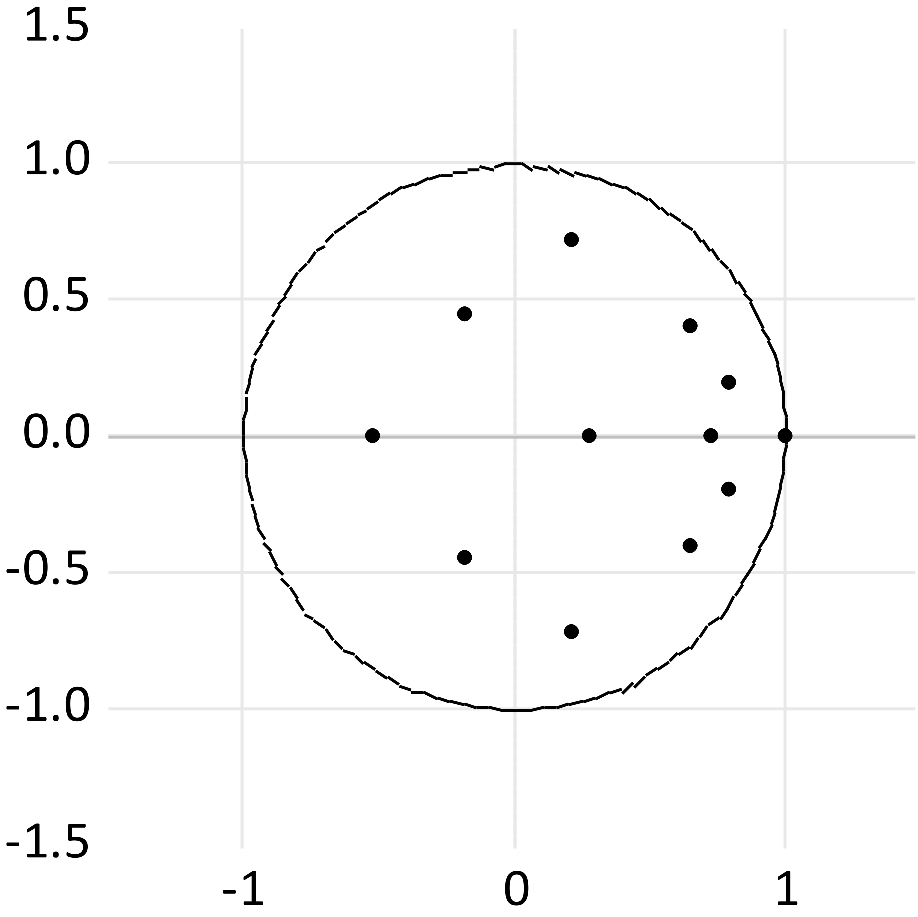

Figure 5.3: Inverse roots of the AR characteristic polynomial

Source: Own Computation (2021)

Figure 5.3 illustrates the inverse roots of the Autoregressive (AR) characteristic polynomial, in which most inverse roots are within the borders of the circle and one on the circle line. These results imply that the Vector Autoregressive model is stable. Furthermore, the modulus for the roots is less than 1 which shows that the system is stationary.

5.8.3 Heteroscedasticity

The heteroscedasticity test was used to check the existence of inconsistency of the variance to avoid bias and poor performance of the VAR model. When there is no existence of heteroscedasticity then the VAR model is unbiased and produces robust estimations.

5.8.3.1 Test on individual components

Table 5.10: Heteroscedasticity test results on individual components

Dependent	R-squared	F (24,10)	Prob.	Chi-sq (24)	Prob.
Res1*res1	0.550876	0.511066	0.9136	19.28067	0.7369
res2*res2	0.896603	3.613121	0.0194	31.38112	0.1431
res3*res3	0.632086	0.715843	0.7596	22.12299	0.5719
res4*res4	0.853664	2.430666	0.0724	29.87825	0.1888
res5*res5	0.758568	1.309149	0.3391	26.54989	0.3259
res6*res6	0.750843	1.255641	0.3668	26.27951	0.3391
res2*res1	0.798966	1.655952	0.2049	27.96381	0.2616
res3*res1	0.624747	0.693694	0.7780	21.86613	0.5873
res3*res2	0.739617	1.183538	0.4074	25.88658	0.3589
res4*res1	0.725130	1.099203	0.4602	25.37956	0.3854
res4*res2	0.588160	0.595052	0.8563	20.58558	0.6630
res4*res3	0.841590	2.213636	0.0955	29.45565	0.2035
res5*res1	0.843626	2.247884	0.0914	29.52691	0.2009
res5*res2	0.903417	3.897421	0.0148	31.61960	0.1367
res5*res3	0.803871	1.707784	0.1903	28.13548	0.2544
res5*res4	0.774908	1.434428	0.2823	27.12178	0.2988
res6*res1	0.636002	0.728029	0.7494	22.26008	0.5637
res6*res2	0.474485	0.376206	0.9758	16.60696	0.8649
res6*res3	0.561363	0.533246	0.8996	19.64771	0.7166
res6*res4	0.674095	0.861823	0.6373	23.59331	0.4850
res6*res5	0.523912	0.458522	0.9428	18.33692	0.7864
* Denotes no heteroscedasticity: Prob.>0.05					

Source: Own Computation (2021)

Table 5.10 shows the results of the Heteroscedasticity test on individual components. The results validate that there is no heteroscedasticity problem since all the probability values are greater than the 0.05 level of significance, the test was made at a 5% level of significance.

5.8.3.2 Joint Heteroscedasticity test

Table 5.11: Joint Heteroscedasticity test

Test	H_0	df	T-statistic	Prob.	Conclusion
Chi-sq.	No heteroscedasticity	504	525.1318	0.2491	Accept H_0, Prob. Is greater than 0.05. Therefore, there is no heteroscedasticity
Accept H_0: if Prob. >0.05					

Source: Own computation (2021)

5.8.4 Normality test

The normality test establishes the probability distribution of residuals which is one of the assumptions of the Ordinary Least Squares (OLS) method. The estimates of a model are best linear and unbiased if the residuals follow the normal distribution with zero mean and constant variance. This study used VAR Residual Normality Tests, Cholesky (Lutkepohl) and results are presented in Table 5.12.

Table 5.12: VAR Residual Normality Tests, Cholesky (Lutkepohl)

Component	**Skewness**	**Chi-sq**	**df**	**Prob.***
1	0.681677	2.710656	1	0.0997
2	0.439981	1.129235	1	0.2879
3	-0.026239	0.004016	1	0.9495
4	0.354811	0.734363	1	0.3915
5	0.300509	0.526782	1	0.4680
6	0.235003	0.322153	1	0.5703
Joint		5.427206	6	0.4903
Component	**Kurtosis**	**Chi-sq**	**df**	**Prob.**
1	2.529783	0.322443	1	0.5701
2	3.268545	0.105170	1	0.7457
3	2.466333	0.415335	1	0.5193
4	2.530958	0.320835	1	0.5711
5	4.046593	1.597395	1	0.2063
6	2.489641	0.379847	1	0.5377

Joint	3.141024	6	0.7910
Component	**Jarque-Bera**	**df**	**Prob.**
1	3.033099	2	0.2195
2	1.234405	2	0.5395
3	0.419351	2	0.8108
4	1.055198	2	0.5900
5	2.124177	2	0.3457
6	0.702001	2	0.7040
Joint	8.568230	12	0.7393

Source: Own Computation (2021)

Table 5.12 shows the vector autoregressive residual normality tests based on the Cholesky (Lutkepohl) technique which results in three normality tests called Skewness, Kurtosis, and Jarque-Bera tests. This study included all three tests for the viability of results. The null hypothesis is that the residuals are normally distributed, and the alternative hypothesis is that residuals are not normally distributed.

Based on Table 5.11, the results show that the Skewness test statistic is 5.42720 and the P-value is 0.4903 which is greater than 0.05 (5%). Additionally, the Kurtosis test statistic is 3.141024 and the P-value is 0.7910 which is greater than 0.05 (5%). Finally, the Jarque-Bera test statistic is 8.568230 with a P-value of 0.7393 which is greater than 0.05 (5%). Therefore, the null hypothesis is accepted that the residuals are normally distributed since the P-values of all the tests are greater than 0.05 (5%). This decision is derived from the decision rule stated in the methodology chapter.

5.9 Impulse response analysis

The Vector autoregressive (VAR) system allows the analysis of the impulse response of endogenous variables to shocks of other variables in the same system. Impulse response analysis was used to demonstrate the unitary shock on each selected variable. Impulse response analysis traces the effects of a one-time shock to one or more responses of independent variables. Through impulse response analysis, the transmission that occurs between one variable to another can be assessed (Rizwan *et al.,* 2017) and the findings of this study are presented in Figure 5.4 to 5.9. The positive effect is indicated by the middle line above (0.0), and the negative effect is indicated by the middle line below 0.0.

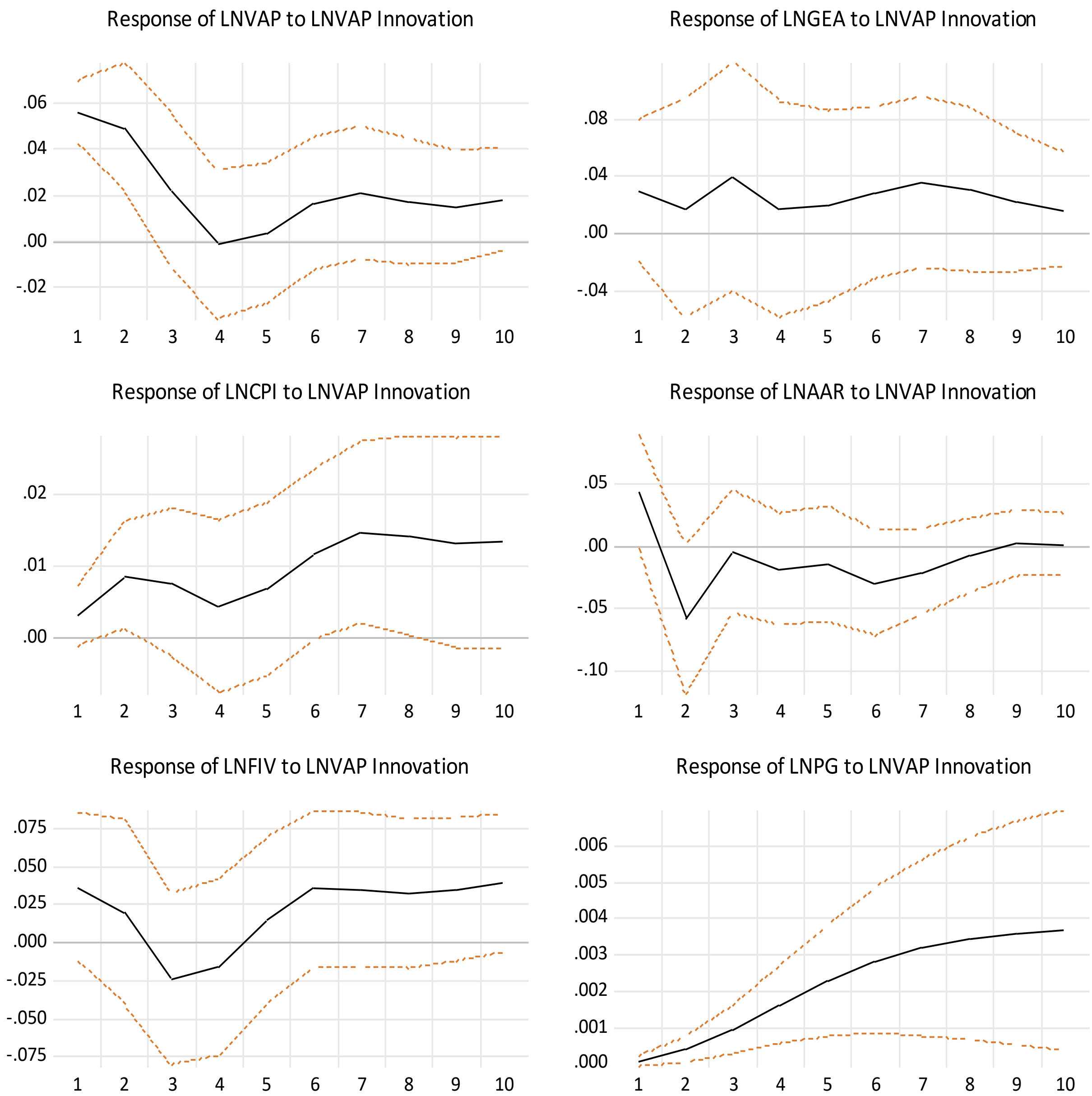

Figure 5.4: Impulse responses to the value of agricultural production

Source: Own Computation (2021)

The value of agricultural production (VAP) transmits positive shocks to the value of agricultural production, government expenditure in agriculture (GEA), consumer price index (CPI), and population (PG) for the period of 10 years, while average annual rainfall (AAR) and food import value (FIV) receives both positive and negative shocks. VAP responds positively to the shocks of itself, and this is in line with what the study recorded in Table 5.8 have shown. Even though VAP transmits negative and positive shocks to AAR and PG respectively, there might be no economic sense derived from the relation.

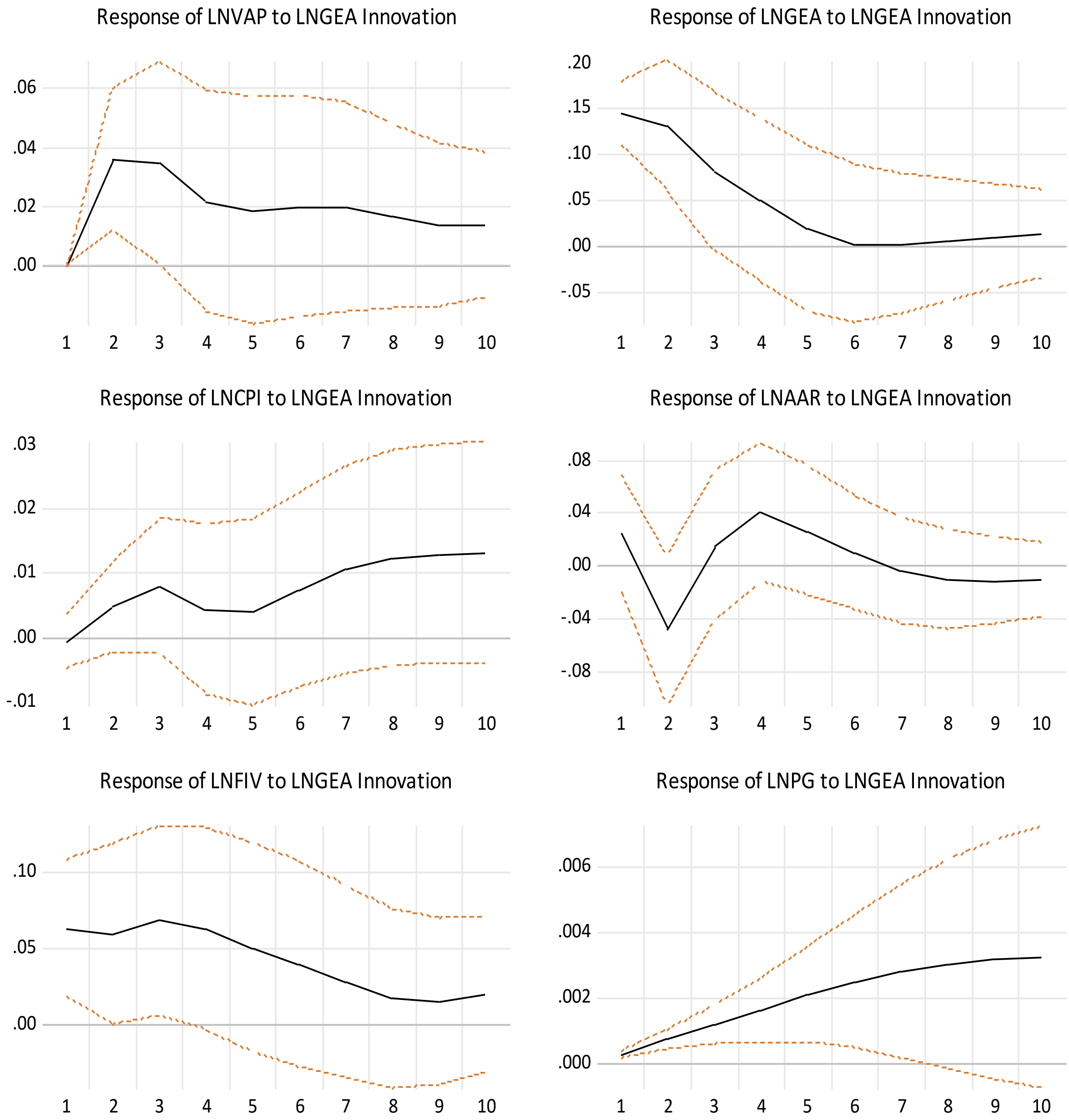

Figure 5.5: Impulse responses to government expenditure in agriculture

Source: Own Computation (2021)

Government expenditure in agriculture (GEA) transmits positive shocks to GEA, value of agricultural production (VAP), consumer price index (CPI), food import value (FIV), while average annual rainfall (AAR) receives both positive and negative shocks. However, as stated in the discussion of the VAR model results, the relationship between GEA and AAR is not direct. The result that GEA transmits positive shocks to VAP is in line with what the study recorded in tables 5.7 and 5.8.

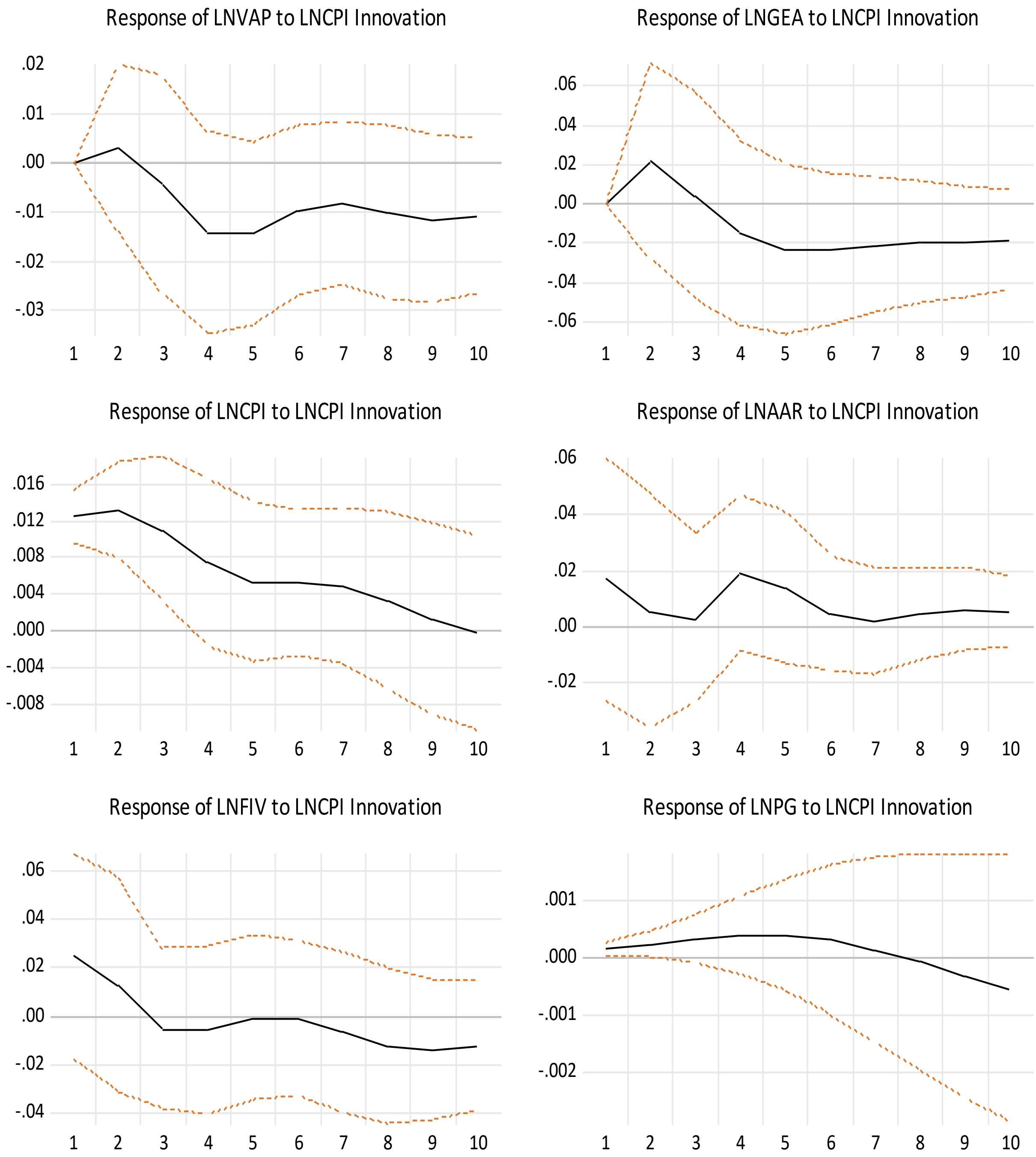

Figure 5.6: Impulse responses to the consumer price index

Source: Own Computation (2021)

The consumer price index (CPI) transmits positive shocks to CPI for the period of 10 years. The value of agricultural production (VAP), government expenditure in agriculture (GEA), average annual rainfall (AAR), food import value (FIV), and population (PG) receive both positive and negative shocks from CPI in the period of 10 years. Both VAP and GEA respond negatively fast to the shocks of CPI as compared to AAR, FIV, and PG since they start responding negatively from year 2.

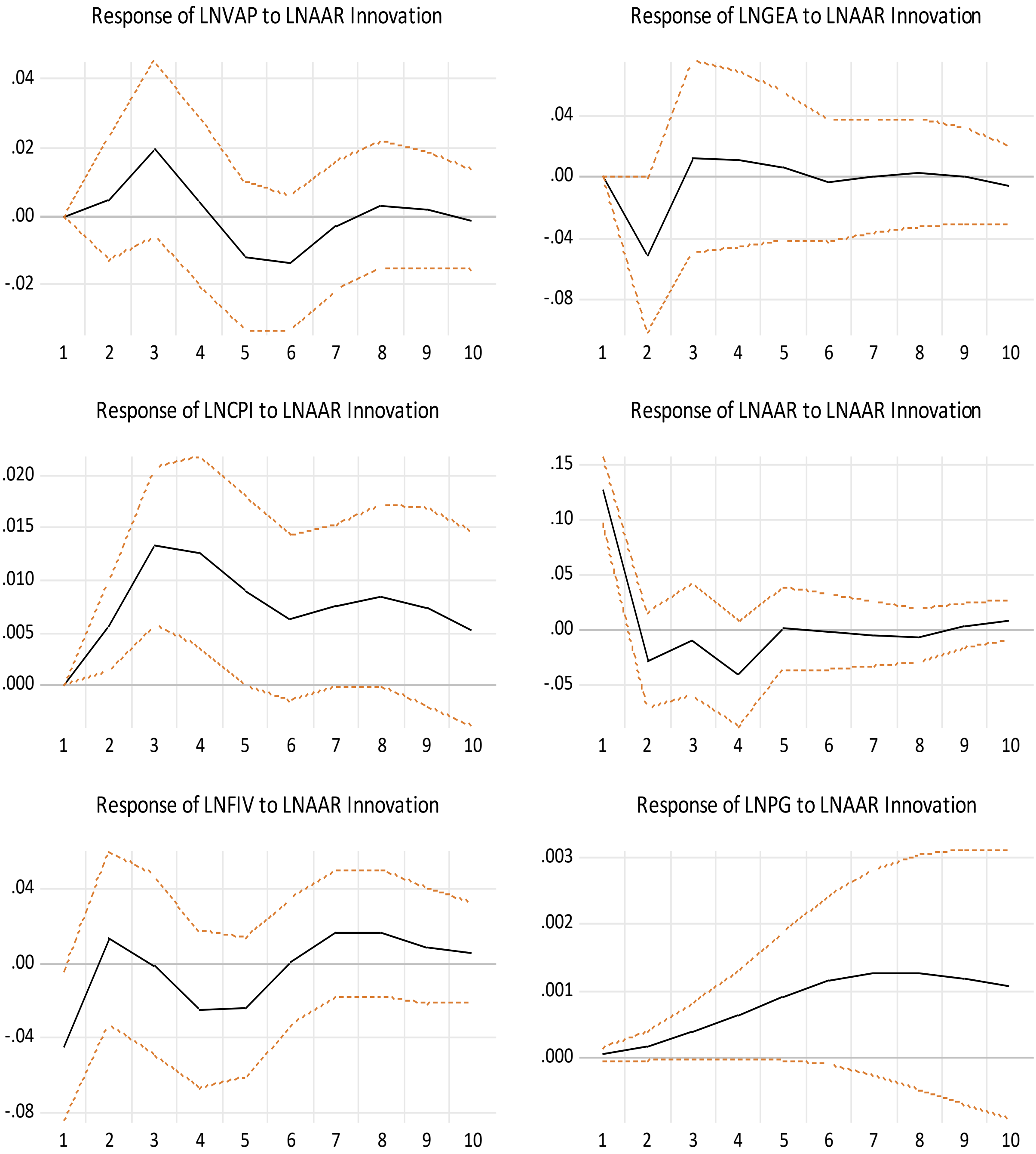

Figure 5.7: Impulse responses to average annual rainfall

Source: Own Computation (2021)

Average annual rainfall (AAR) transmits positive shocks to consumer price index (CPI) and population (PG) for the 10 years period. AAR, value of agricultural production (VAP), government expenditure in agriculture (GEA), and food import value (FIV) receive both negative and positive shocks. In the VAR model result discussion, it was stated that the relationship between rainfall and CPI is not direct. Instead, rainfall affects agricultural production and agricultural production directly affects the consumer price index.

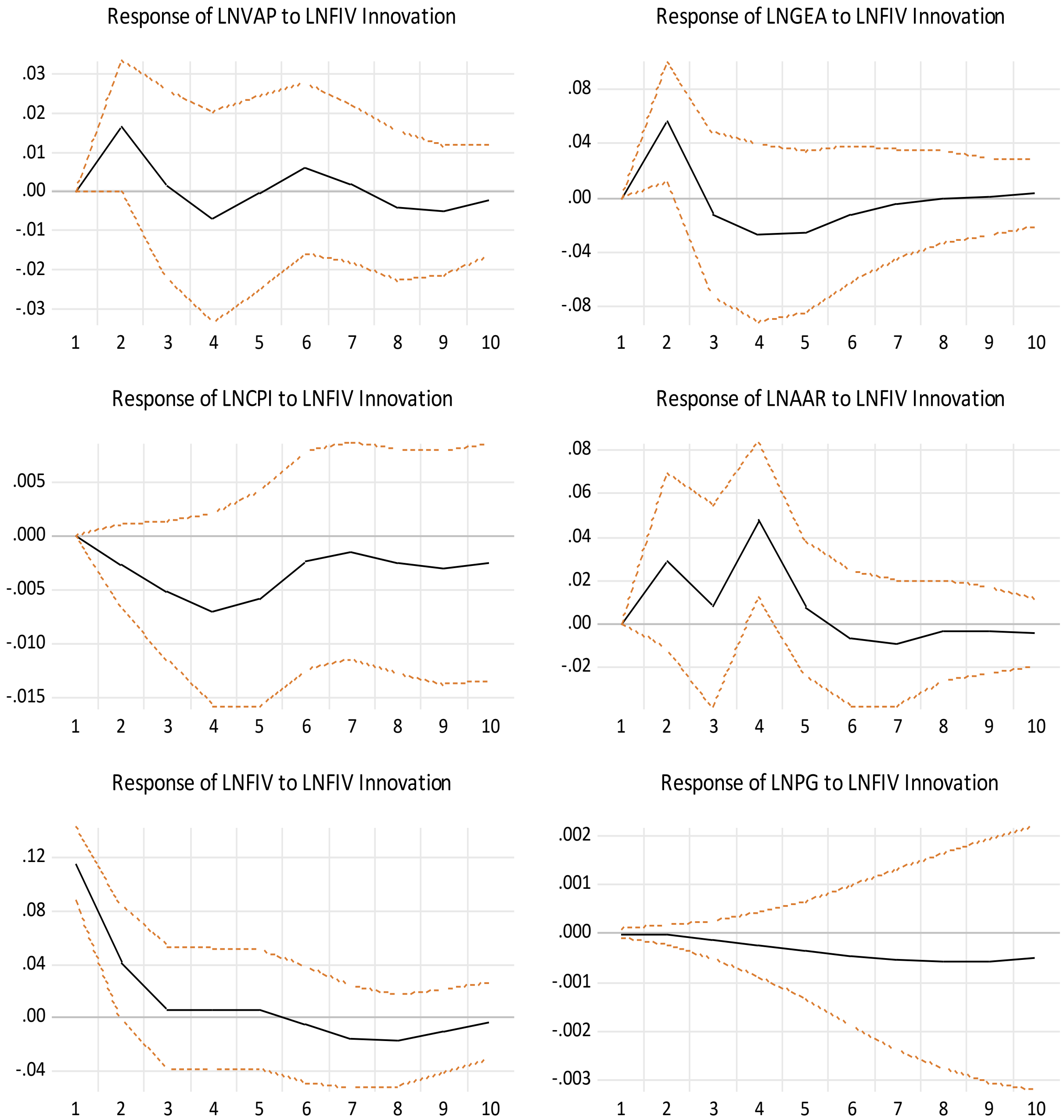

Figure 5.8: Impulse responses to food import value

Source: Own computation (2021)

From figure 5.8, it is evident that VAP, GEA, CPI, and FIV receive both positive and negative shocks of FIV while CPI and PG receives only negative shocks for the whole period of 10 years. FIV responds positively to itself in the short-run with a downward slopping curve. However, FIV also responds negatively to itself in the long-run. VAP receives positive and negative shocks from food import value both in the short-run. GEA responds positively to the shocks of FIV in the short-run, but negatively in the long-run.

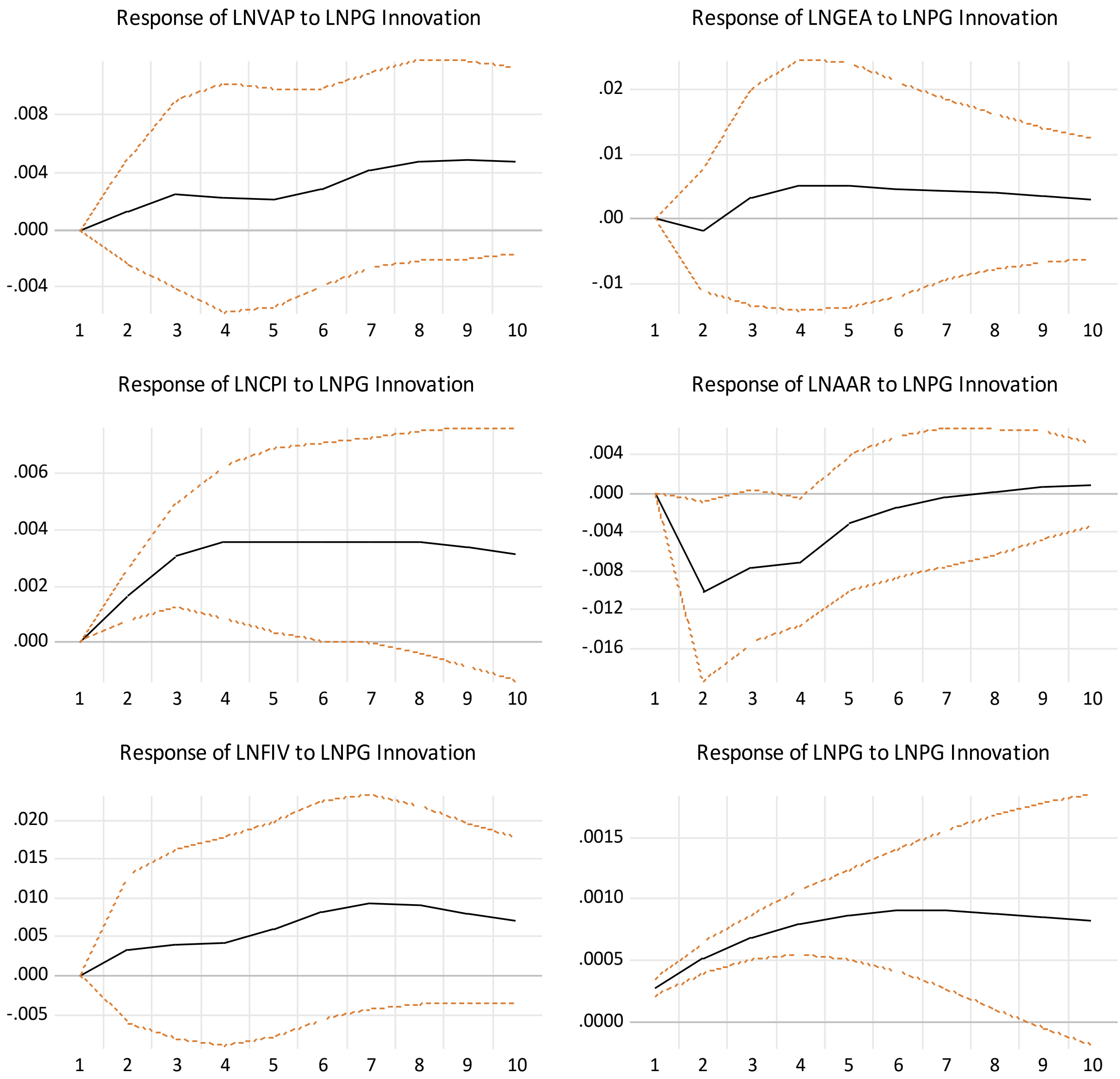

Figure 5.9: Impulse responses to population

Source: Own Computation (2021)

Population (PG) transmits positive shocks to the value of agricultural production (VAP), government expenditure in agriculture (GEA), consumer price index (CPI), food import value (FIV), and PG for the period of 10 years. Average annual rainfall (AAR) receives both positive and negative shocks of PG. Even though the relationship between AAR and PG might not be direct, AAR responds negatively to the shocks of PG. However, AAR starts responding positively in the 7th year.

5.10 Variance decomposition

Variance decomposition provides details on the amount that each variable contributes to other variables in the autoregression system. Additionally, variance decomposition specifies how much of the forecast error variance of each variable can be explained by the shocks of other variables. Simply, variance decomposition determines how much a change in endogenous variables is going to the fluctuation in the exogenous variable over time. The interpretation in this area of variance decomposition is based on period three in the short-run and period four to ten in the long run. Cholesky order of variables has been used in this results presentation. The tables given under this test show the aggregate results of such decomposition.

Table 5.13: Variance decomposition of lnVAP

Period	S. E	lnVAP	lnGEA	lnCPI	lnAAR	lnFIV	lnPG
1	0.056	100.000	0.000	0.000	0.000	0.000	0.000
2	0.085	77.445	18.117	0.138	0.345	3.931	0.021
3	0.096	65.136	26.948	0.324	4.435	3.074	0.080
4	0.100	60.341	29.702	2.256	4.308	3.266	0.124
5	0.104	56.448	31.013	3.996	5.331	3.050	0.159
6	0.108	53.978	31.826	4.443	6.435	3.099	0.218
7	0.113	53.541	32.559	4.640	6.019	2.901	0.336
8	0.116	52.877	32.878	5.132	5.774	2.844	0.491
9	0.118	52.279	32.819	5.831	5.549	2.881	0.638
10	0.121	52.189	32.624	6.335	5.306	2.781	0.762

Source: Own Computation (2021)

The results in Table 5.13 indicate that shocks of the value of agricultural production (VAP) were the main drivers of VAP in South Africa as compared to other selected variables. Therefore, these findings mean that the South African value of agricultural production in the context of the VAR system used in the study can be predicted by its previous behaviour. After the first year, the main influence on South Africa's VAP was government expenditure in agriculture shocks (lnGEA, accounting 18.11%), followed by food import value (lnFIV, accounting 3.93%), consumer price index (lnCPI, accounting 0.13%), and average annual rainfall (lnAAR, accounting 0.34%). The magnitude of population contribution to VAP did not change significantly between the 2nd year and the 10th year (lnPG, contributing 0.02% to 0.76%), meaning that the population did not have a significant effect on the value of agricultural production. These findings are in line with the findings of the VAR model recorded in Table 5.8.

Table 5.14: Variance decomposition of lnGEA

Period	S. E	lnVAP	lnGEA	lnCPI	lnAAR	lnFIV	lnPG
1	0.148	4.055	95.944	0.000	0.000	0.000	0.000
2	0.214	2.632	83.800	0.992	5.852	6.714	0.007
3	0.233	5.085	82.851	0.862	5.221	5.953	0.026
4	0.241	5.222	81.651	1.178	5.101	6.778	0.067
5	0.245	5.672	79.532	2.036	5.016	7.630	0.110
6	0.248	6.840	77.541	2.873	4.905	7.697	0.140
7	0.252	8.688	75.368	3.490	4.767	7.517	0.167
8	0.2551	9.916	73.844	4.014	4.677	7.359	0.188
9	0.257	10.475	72.923	4.534	4.609	7.253	0.204
10	0.258	10.742	72.294	4.975	4.596	7.176	0.215

Source: Own Computation (2021)

According to Table 5.14, the variation of government expenditure in agriculture (GEA) is explained mostly by the shocks of GEA over the period of 10 years (accounting for almost 96% to 72% from year 1 to year 10 respectively). These findings mean that the South African government expenditure in agriculture can be predicted by its previous behaviour. The main driver of government expenditure in agriculture from the 2nd year was the value of agricultural production (lnVAP, accounting for 2.63% to 10.74% in the 10th year), followed by food import value (lnFIV, accounting for 6.71% in the second year to 7% in the 10th year), and average annual rainfall (lnAAR, accounting 5.85%). Consumer price index shocks accounted for 0.9% in the second year. However, the magnitude of CPI shocks to GEA increase from 0.99% to almost 5% on the 10th year, meaning that consumer price index in South Africa played a big role in the reduction of government expenditure in agriculture in line with what the study recorded in Table

5.7. Population shocks accounted the least in the variation of GEA as compared to other variables for the whole period of 10 years.

Table 5.15: Variance decomposition of lnCPI

Period	**S. E**	**lnVAP**	**lnGEA**	**lnCPI**	**lnAAR**	**lnFIV**	**lnPG**
1	0.012	5.691	0.184	94.123	0.000	0.000	0.000
2	0.021	17.350	4.827	69.040	6.596	1.603	0.581
3	0.030	15.097	9.292	48.167	22.436	3.683	1.322
4	0.035	12.742	8.419	40.384	29.697	6.754	2.000
5	0.038	13.946	8.254	36.343	30.699	8.169	2.585
6	0.041	19.481	10.027	32.208	28.176	7.207	2.900
7	0.046	25.547	13.270	27.026	25.315	5.910	2.928
8	0.050	28.800	16.827	22.701	23.653	5.120	2.896
9	0.054	30.531	20.081	19.619	22.182	4.717	2.868
10	0.058	32.150	22.872	17.352	20.448	4.353	2.822

Source: Own Computation (2021)

The findings in Table 5.15 shows that the main driver of consumer price index (CPI) in the short-run (1^{st} and 2^{nd} year) is consumer price (lnCPI, accounting 94%). However, the main drivers of CPI from the 8^{th} year were the value of agricultural production (lnVAP, accounting 29%) and average annual rainfall (lnAAR, accounting almost 24%). The effect of AAR shocks on CPI supports what the study recorded in section 5.7.1.2, where it was discussed that AAR increases CPI but the relationship between the two variables is indirect. The shocks of government expenditure (GEA) on CPI increased from 0.18% in the 1^{st} year to 22.87% in the tenth year. Therefore, these findings shows that the main drivers of the South African consumer price index in the long-run contemplating the study period were VAP, GEA, and ARR and the least drivers were food import value (FIV) and population (PG). Meaning that the shocks of FIV and PG were not significant on the variation of CPI.

Table 5.16: Variance decomposition of lnAAR

Period	S. E	lnVAP	lnGEA	lnCPI	lnAAR	lnFIV	lnPG
1	0.138	9.749	3.156	1.488	85.605	0.000	0.000
2	0.163	19.823	11.088	1.163	64.321	3.216	0.386
3	0.164	19.560	11.757	1.171	63.503	3.412	0.594
4	0.182	16.909	14.593	2.033	56.278	9.549	0.636
5	0.185	16.905	16.112	2.510	54.442	9.384	0.644
6	0.188	18.908	15.882	2.497	52.841	9.238	0.631
7	0.189	19.815	15.679	2.472	52.080	9.329	0.622
8	0.190	19.830	15.906	2.515	51.829	9.298	0.618
9	0.191	19.741	16.173	2.603	51.585	9.279	0.617
10	0.191	19.623	16.364	2.667	51.464	9.264	0.615

Source: Own Computation (2021)

The findings shows that the main driver of average annual rainfall (AAR) in South Africa is AAR. Other factors that influenced ARR mostly in South Africa in the study period include the value of agricultural production (lnVAP, accounting 9.74% in the 1st year and 19.62% in the 10th year) and government expenditure in agriculture (lnGEA, accounting 3% in the first year and 16% in the 10th year). These findings support what the study recorded in section 5.7.1.3 where it was discussed that the relationship between government expenditure in agriculture and average annual rainfall is not direct. Furthermore, these findings shows that as much as government expenditure in agriculture in South Africa is considered a driver of average annual rainfall, the relationship between the two variables is bilateral because it was discussed under Table 5.14 that average annual rainfall is one of the drivers of government expenditure in agriculture.

Table 5.17: Variance decomposition of lnFIV

Period	S. E	lnVAP	lnGEA	lnCPI	lnAAR	lnFIV	lnPG
1	0.145	6.245	18.971	2.890	9.339	62.553	0.000
2	0.164	6.329	27.767	2.862	8.019	54.980	0.039
3	0.180	7.113	37.550	2.475	6.708	46.069	0.082
4	0.193	6.894	43.096	2.239	7.507	40.142	0.120

5	0.201	6.890	45.599	2.057	8.307	36.950	0.194
6	0.208	9.281	46.187	1.920	7.747	34.524	0.338
7	0.215	11.383	45.240	1.906	7.874	33.086	0.509
8	0.219	12.988	43.880	2.130	8.078	32.269	0.653
9	0.224	14.897	42.706	2.416	7.937	31.288	0.752
10	0.228	17.165	41.700	2.609	7.672	30.035	0.816

Source: Own Computation (2021)

Based on Table 5.17, the variation in food import value (FIV) is mainly explained by FIV in the period of 10 years. These findings mean that FIV in South Africa can be explained by its own past values. Main drivers of FIV in South Africa from the 1st year were shocks of government expenditure in agriculture (lnGEA, accounting 19%), average annual rainfall (lnAAR, accounting 9%), and the value of agricultural production (lnVAP, accounting 6%). Population (PG) shocks accounted less in the variation of FIV as compared to other selected variables accounting 0.03% and 0.8% in 2nd year and 10th year respectively. In addition, the magnitude of population shocks did not increase drastically for the period of 10 years, meaning that population is not significant in predicting FIV in line with what the study recorded in Table 5.7 of the VAR model results.

Table 5.18: Variance decomposition of lnPG

Period	S. E	lnVAP	lnGEA	lnCPI	lnAAR	lnFIV	lnPG
1	0.000	4.447	35.048	12.035	1.078	0.018	47.370
2	0.001	13.363	48.228	6.037	2.492	0.116	29.762
3	0.002	25.205	45.977	4.122	4.414	0.476	19.804
4	0.003	34.677	42.409	2.984	5.423	0.758	13.746
5	0.004	40.524	40.089	2.112	6.317	0.947	10.008
6	0.006	43.672	38.984	1.448	6.979	1.100	7.814
7	0.007	45.478	38.570	0.975	7.275	1.233	6.467
8	0.009	46.691	38.578	0.705	7.157	1.293	5.574
9	0.010	47.592	38.784	0.628	6.776	1.280	4.938
10	0.011	48.227	39.066	0.726	6.283	1.229	4.466

Source: Own Computation (2021)

According to Table 5.18, the variation of the population is mainly explained by population (PG) in the short-run (2 years) and by the value of agricultural production (VAP) and government expenditure in agriculture (GEA) in the long-run (10 years). Meaning that PG can be predicted by its own past values only in the short-run. However, PG is mainly influenced by VAP and GEA in the long-run, meaning that the shocks of VAP and GEA contribute significantly to the variation of the South African population even though the contribution might not be direct. CPI shocks accounted for a proportion of 12.03% in the first year, the proportion declined sharply to 0.72% in the tenth year. AAR had a proportion of 0.07% in the first year which increased to 6.38% in the tenth year. Finally, FIV shocks accounted for a proportion of 0.01% in the first year which increased to 1.22% by the tenth year.

5.11 Summary

This chapter presented and discussed the econometric results of the study. Additional information on the data used as well as some analysis tables are provided in the Appendix. This chapter established 9 sections in which the first one gave descriptive statistics of the data set. The second section gave stationarity tests using the Augmented Dickey-Fuller test. The data was found to be stationary at first difference as indicated by the results in Table 5.7. For the VAR model implementation, two lags were chosen using the automatic lag selection criteria shown in Table 5.3. Section four used the Johansen cointegration test to test for the long-run relationship and found that 3 equations were cointegrating as indicated in Table 5.4. Furthermore, results for cointegration on the value of agricultural production and government expenditure showed that there is a long-run relationship between the two variables as indicated in Table 4.5.

The fifth section gave results of the Granger causality test in which food import value was found to Granger cause the value of agricultural production. The chapter also gave results of the Vector autoregressive model (VAR) as shown in Table 5.7. Table 5.8 further gave results of the VAR model only focusing on the value of agricultural production as the dependent variable. The results showed that the value of agricultural production, government expenditure in agriculture, and food import value is positive in determining the value of agricultural production and they are statistically significant.

Other variables that are positive towards the value of agricultural production include average annual rainfall and population.

The chapter also gave the results of diagnostic tests. Autocorrelation was tested using the residual portmanteau test and no autocorrelation was found to exist in the data. The chapter also gave results of the stability test using the Inverse Roots of the Autoregressive characteristic polynomial and the model was found to be stable. Heteroscedasticity was tested on individual residuals and presented in Table 5.9, and on joint basis represented in Table 5.10. Both results on heteroscedasticity showed that no heteroscedasticity problem exists on the data. The chapter also gave results for normality based on Skewness, Kurtosis, and Jarque-Bera models. All the tests for normality showed that the residuals are normally distributed. The chapter gave results of the impulse analysis for all variables. Lastly, the chapter gave results of the variance decomposition of all variables.

CHAPTER 6

SUMMARY, CONCLUSION, AND POLICY RECOMMENDATIONS

6.1 Introduction

This chapter summarises the main findings of the study. Additionally, the chapter gives conclusions based on the findings and gives policy recommendations. Furthermore, the chapter gives suggestions on areas that can be researched in the future. Lastly, the chapter gives an overview of the limitations of this study.

6.2 Summary of findings

The study aimed to examine the relationship between the value of agricultural production, government spending in agriculture, annual average rainfall, consumer price index, food import value, and population. The first objective was to analyse the short-run and long-run relationship between government spending in agriculture and the value of agricultural production. The study used the Johansen cointegration test to check the long-run relationship between the two variables. The study found that the value of agricultural production and government expenditure in agriculture have a long-run relationship. The study used the Vector autoregressive (VAR) model to check the short-run relationship between the value of agricultural production and government expenditure in agriculture. The estimated model found that a one-year lagged government expenditure in agriculture has a positive significant relationship with the value of agricultural production.

The second objective was to determine the causality between government spending in agriculture and the value of agricultural production. The study used the Granger causality test to address this objective. The results of the Granger causality test showed that government expenditure in agriculture does not granger cause the value of agricultural production and the value of agricultural production does not granger cause government expenditure in agriculture.

The third objective was to determine the relationship between the value of agricultural production and selected independent variables: government spending in agriculture, annual average rainfall, consumer price index, food import value, and population. The study used the VAR model to address this objective.

The study found that the one-year lagged value of agricultural production, one-year lagged government expenditure in agriculture, and one-year lagged food import value have a positive significant relationship with the value of agricultural production. Additionally, the one-year lagged value of agricultural production and one-year lagged government expenditure in agriculture have the greatest positive significant effect on the value of agricultural production, contributing 63.87% and 16.19% respectively. Even though a one-year lagged food import value was found to have a positive significant relationship with the value of agricultural production, the two-year lagged food import value was found to have a negative significant relationship with the value of agricultural production.

In both one-year lag and two-year lag basis, the study found that consumer price index, average annual rainfall, and population have an insignificant relationship with the value of agricultural production. Even though the one-year lagged consumer price index reduces the value of agricultural production by 20.45% and the two-year lagged consumer price index reduces the value of agricultural production by 50.49%, the consumer price index does not have the greatest negative impact because of its relationship with the value of agricultural production is statistically insignificant. Therefore, the variable that has the greatest negative impact on the value of agricultural production is food import value since its relationship with the value of agricultural production is statistically significant and reduces the value of agricultural production by 23.45% on a two-year lagged basis.

6.3 Conclusions

This study had three hypotheses and they were all tested.

Hypothesis one: The null hypothesis that there is no significant long-run and short-run relationship between government expenditure in agriculture and the value of agricultural production was rejected because the Johansen cointegration test proved that there is a long-run relationship between the two variables. Furthermore, the VAR model proved that there is a short-run relationship between government expenditure in agriculture and the value of agricultural production.

Hypothesis two: The null hypothesis that there is no causality between government expenditure in agriculture and the value of agricultural production cannot be rejected because the Granger causality test proved that the value of agricultural production does not granger cause government expenditure in agriculture and government expenditure in agriculture does not granger cause the value of agricultural production.

Hypothesis three: The null hypothesis that there is no relationship between the value of agricultural production and selected independent variables: government spending in agriculture, annual average rainfall, consumer price index, food import value, and the population was rejected because the VAR model results proved that all selected variables have either a positive or negative effect towards the value of agricultural production.

6.4 Recommendations

This study researched the main problem of the fluctuating value of agricultural production as stated in the problem statement. Given the positive influence of government expenditure on the value of agricultural production, it is recommended that the government should increase its expenditure on the agricultural sector. Increasing government expenditure will enable the agricultural sector to produce better quality research and enhance modern efficient technology aimed at increasing agricultural production and stabilizing the value of agricultural production. In addition, the government should increase its spending in the agricultural sector by investing in research related to climate-smart agriculture. Investing in climate-smart research will ensure that climate-friendly technologies are developed and adopted. Climate-smart technologies will reduce carbon dioxide emissions and increase rainfall which is efficient for the agricultural sector as discussed in section 5.7.1.3.

The study found that there is a negative relationship between the consumer price index and the value of agricultural production. An increase in the consumer price index decreases the value of agricultural production. It is recommended that policymakers review the monetary policy of South Africa which controls inflation (measured in the consumer price index) to ensure price stability. This will ensure that prices grow at an average pace rather than drastically changing. Subsequently, the value of agricultural production which is measured as the gross price of agricultural production output at farm-gate will be sustained from fluctuating.

The study found that food import value granger causes the value of agricultural production, and the study also found that there is a negative relationship between the value of agricultural production and food import value. Therefore, it is recommendable that the South African government should discourage imports and encourage South African agricultural producers to produce more major imported food products such as rice, wheat, palm oil, cane sugar, chicken cuts and offal, whiskies, sunflower oil, and soybean meal as reported by the International Trade Administration (2022). Engaging in producing the aforementioned products locally will ensure that South Africa imports less of them and thus lowering the food import value and ultimately stabilising the value of agricultural production.

6.5 Limitations of the study

This study might not have focused on all variables that affect the value of agricultural production due to limited data availability and time. Additionally, the study referenced literature that was on agricultural output and agricultural productivity because the literature related to the value of agricultural production is very limited. However, this meant that this study could add to the knowledge that is limited in terms of analysing the specific variable of the value of agricultural production.

6.6 Suggestions for further studies

To add more literature concerning the value of agricultural production, future research can investigate the effect of other variables such as interest rates, policy reforms, land, temperature, the value of exports, and fuel prices. In addition, future research can focus on modelling technical and allocative efficiencies of government expenditure in agriculture.

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APPENDIXES

APPENDIX 1: DATA

Year	VAP	GEA	AAR	CPI	FIV	PG
1983	7881,4	833	373,4	9,616959	1073,9	30993,76
1984	8774,4	1220	400,9	10,72546	1682	31841,59
1985	10933,9	1565	504,5	12,47309	1298,3	32678,87
1986	11381	1706	428,8	14,79993	1473,4	33495,95
1987	13348,8	1571	471,9	17,19169	1511,1	34297,73
1988	16175,9	2058	592,4	19,38871	2081,4	35100,91
1989	19334,8	2110	513,4	22,24483	2079	35930,05
1990	20198	2055	388,8	25,43051	1936,2	36800,51
1991	21952,4	2240	506,7	29,33023	2257,8	37718,95
1992	22126,8	2817	314,2	33,39971	4477,9	38672,61
1993	25723,7	5868	450	36,64531	3813,1	39633,75
1994	28162,4	3717	389,7	39,92086	4894,9	40564,06
1995	29941,3	3239	501,4	43,38616	6834,3	41435,76
1996	36519,3	3651	567,4	46,57684	7745,2	42241,01
1997	40458,3	3623	486,2	50,58141	8641,5	42987,46
1998	43117,4	3885	495,6	54,06169	9401,6	43682,26
1999	44669,7	3746	435,7	56,86289	8963,8	44338,54
2000	46660,9	3743	624,4	59,89877	9644,1	44967,71
2001	52185,6	4224	538,5	63,31414	10704,4	45571,27
2002	68283	5190	408,9	69,32563	15162,6	46150,91
2003	72931,5	5855	360,5	73,26293	13910,5	46719,2
2004	73583,5	7192	467,7	72,75593	16415,5	47291,61
2005	77112,6	6806	384,9	74,25677	16286,4	47880,6
2006	79152,1	9156	580,6	76,66559	20588,5	48489,46
2007	98535,1	10221	409,1	81,40185	29304,5	49119,76
2008	129164,3	13418	435,7	89,58703	38427,5	49779,47

2009	134566,9	14639	485,8	96,09514	35039,2	50477,01
2010	132654,9	13591	477,6	100	39531,6	51216,96
2011	144588,2	15868	557,9	105,0172	50798,7	52003,76
2012	168591,1	17082	378	111,0283	59563,5	52832,66
2013	184623,9	18708	399,4	117,4417	64251,9	53687,12
2014	209472,3	20219	461,6	124,648	67243,2	54544,19
2015	224792	20159	338,4	130,2686	76888,8	55386,37
2016	244001,2	20330	405,8	138,8593	92203,9	56207,65
2017	269413,1	21785	415,8	146,0537	87630	57009,76
2018	286095,9	20727	383	152,6328	87004,8	57792,52
2019	284383,2	22289	381,9	158,9279	91688,9	58558,27

APPENDIX 2: DESCRIPTIVE STATISTICS

	VAP	GEA	CPI	AAR	FIV	PG
Mean	91391.64	8570.432	69.29939	451.7973	26823.08	45083.78
Median	52185.60	5190.000	63.31414	435.7000	10704.40	45571.27
Maximum	286095.9	22289.00	158.9279	624.4000	92203.90	58558.27
Minimum	7881.400	833.0000	9.616959	314.2000	1073.900	30993.76
Std. Dev.	86601.48	7291.566	43.95397	75.11357	30449.67	8035.092
Skewness	1.017649	0.713730	0.446555	0.435300	1.065556	-0.086326
Kurtosis	2.759983	1.927244	2.131203	2.461838	2.669251	1.929739
Jarque-Bera	6.475070	4.915526	2.393365	1.614990	7.170348	1.811870
Probability	0.039261	0.085626	0.302195	0.445974	0.027732	0.404164
Sum	3381491.	317106.0	2564.078	16716.50	992453.9	1668100.
Sum Sq. Dev.	2.70E+11	1.91E+09	69550.24	203113.7	3.34E+10	2.32E+09
Observations	37	37	37	37	37	37

APPENDIX 3: JOHANSEN COINTEGRATION (ALL VARIABLES)

Date: 12/12/21 Time: 00:52
Sample (adjusted): 1986 2019
Included observations: 34 after adjustments
Trend assumption: Linear deterministic trend
Series: VAP GEA CPI AAR FIV PG
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 *	0.938838	192.0768	95.75366	0.0000
At most 1 *	0.708963	97.07278	69.81889	0.0001
At most 2 *	0.551569	55.10638	47.85613	0.0090
At most 3	0.424873	27.83837	29.79707	0.0827
At most 4	0.226034	9.030797	15.49471	0.3625
At most 5	0.009340	0.319057	3.841465	0.5722

Trace test indicates 3 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 *	0.938838	95.00406	40.07757	0.0000
At most 1 *	0.708963	41.96640	33.87687	0.0044
At most 2	0.551569	27.26801	27.58434	0.0548
At most 3	0.424873	18.80757	21.13162	0.1026
At most 4	0.226034	8.711740	14.26460	0.3109
At most 5	0.009340	0.319057	3.841465	0.5722

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

APPENDIX 4: JOHANSEN COINTEGRATION FOR VAP AND GEA

Date: 02/19/22 Time: 18:22
Sample (adjusted): 1986 2019
Included observations: 34 after adjustments
Trend assumption: Linear deterministic trend
Series: VAP GEA
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 *	0.465245	21.61477	15.49471	0.0053
At most 1	0.009735	0.332611	3.841465	0.5641

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 *	0.465245	21.28216	14.26460	0.0033
At most 1	0.009735	0.332611	3.841465	0.5641

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 5: GRANGER CAUSALITY

Pairwise Granger Causality Tests
Date: 12/12/21   Time: 00:59
Sample: 1983 2019
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
DGEA does not Granger Cause DVAP	34	0.24541	0.7840
DVAP does not Granger Cause DGEA		1.59284	0.2206
DCPI does not Granger Cause DVAP	34	0.39003	0.6805
DVAP does not Granger Cause DCPI		2.08565	0.1425
DAAR does not Granger Cause DVAP	34	0.42173	0.6599
DVAP does not Granger Cause DAAR		2.13975	0.1359
DFIV does not Granger Cause DVAP	34	9.92527	0.0005
DVAP does not Granger Cause DFIV		1.46711	0.2472
DPG does not Granger Cause DVAP	34	0.54354	0.5865
DVAP does not Granger Cause DPG		0.29980	0.7432

APPENDIX 6: LOG TRANSFORMED DATA

YEAR	LNVAP	LNGEA	LNCPI	LNAAR	LNFIV	LNPG
1983	8.972261	6.725034	2.263528	5.922650	6.979052	10.34154
1984	9.079594	7.106606	2.372620	5.993712	7.427739	10.36853
1985	9.299623	7.355641	2.523573	6.223568	7.168811	10.39448
1986	9.339701	7.441907	2.694622	6.060991	7.295328	10.41918
1987	9.499182	7.359468	2.844426	6.156767	7.320593	10.44283
1988	9.691278	7.629490	2.964691	6.384182	7.640796	10.46598
1989	9.869662	7.654443	3.102110	6.241055	7.639642	10.48933
1990	9.913339	7.628031	3.235950	5.963065	7.568483	10.51327
1991	9.996632	7.714231	3.378619	6.227919	7.722146	10.53792
1992	10.00454	7.943428	3.508547	5.750030	8.406909	10.56289
1993	10.15517	8.677269	3.601285	6.109248	8.246198	10.58744
1994	10.24574	8.220672	3.686899	5.965377	8.495949	10.61064
1995	10.30699	8.083020	3.770141	6.217404	8.829709	10.63190
1996	10.50560	8.202756	3.841103	6.341065	8.954829	10.65115
1997	10.60803	8.195058	3.923584	6.186620	9.064331	10.66866
1998	10.67168	8.264878	3.990126	6.205769	9.148635	10.68470
1999	10.70705	8.228444	4.040643	6.076954	9.100950	10.69961
2000	10.75066	8.227643	4.092656	6.436791	9.174102	10.71370
2001	10.86256	8.348538	4.148109	6.288787	9.278410	10.72703
2002	11.13142	8.554489	4.238815	6.013471	9.626587	10.73967
2003	11.19728	8.675051	4.294055	5.887492	9.540399	10.75191
2004	11.20618	8.880725	4.287110	6.147827	9.705981	10.76409
2005	11.25302	8.825560	4.307529	5.952984	9.698086	10.77647
2006	11.27913	9.122165	4.339453	6.364062	9.932488	10.78910
2007	11.49817	9.232200	4.399398	6.013960	10.28550	10.80202
2008	11.76884	9.504352	4.495211	6.076954	10.55653	10.81536
2009	11.80982	9.591444	4.565339	6.185797	10.46422	10.82927
2010	11.79551	9.517163	4.605170	6.168774	10.58486	10.84383
2011	11.88164	9.672060	4.654124	6.324180	10.83563	10.85907
2012	12.03523	9.745781	4.709785	5.934894	10.99480	10.87488
2013	12.12608	9.836707	4.765942	5.989963	11.07057	10.89093
2014	12.25235	9.914378	4.825494	6.134699	11.11607	10.90677
2015	12.32293	9.911406	4.869599	5.824229	11.25012	10.92209
2016	12.40493	9.919853	4.933461	6.005860	11.43176	10.93681
2017	12.50400	9.988977	4.983975	6.030204	11.38088	10.95098
2018	12.56408	9.939192	5.028035	5.948035	11.37372	10.96461
2019	12.55808	10.01185	5.068451	5.945159	11.42616	10.97778

APPENDIX 7: VAR RESULTS

Vector Autoregression Estimates
Date: 12/12/21 Time: 01:09
Sample (adjusted): 1985 2019
Included observations: 35 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	LNVAP	LNGEA	LNCPI	LNAAR	LNFIV	LNPG
LNVAP(-1)	0.638779	-0.267575	0.061897	-0.889785	-0.167321	0.002949
	(0.21171)	(0.56009)	(0.04833)	(0.52025)	(0.54881)	(0.00156)
	[3.01730]	[-0.47773]	[1.28081]	[-1.71029]	[-0.30488]	[1.89579]
LNVAP(-2)	-0.073059	0.576168	-0.064910	0.332941	-0.282469	0.004210
	(0.16780)	(0.44393)	(0.03830)	(0.41235)	(0.43499)	(0.00123)
	[-0.43540]	[1.29788]	[-1.69462]	[0.80742]	[-0.64937]	[3.41433]
LNGEA(-1)	0.161955	0.748791	0.031194	-0.360752	0.194284	0.001810
	(0.07776)	(0.20573)	(0.01775)	(0.19110)	(0.20159)	(0.00057)
	[2.08264]	[3.63960]	[1.75730]	[-1.88777]	[0.96376]	[3.16678]
LNGEA(-2)	-0.033866	-0.137518	-0.014016	0.498465	0.297081	-0.000738
	(0.06930)	(0.18333)	(0.01582)	(0.17029)	(0.17964)	(0.00051)
	[-0.48870]	[-0.75010]	[-0.88602]	[2.92710]	[1.65375]	[-1.44875]
LNCPI(-1)	-0.208038	1.150326	0.988190	0.478136	-0.119004	-0.003326
	(0.61726)	(1.63303)	(0.14090)	(1.51686)	(1.60013)	(0.00454)
	[-0.33704]	[0.70441]	[7.01332]	[0.31521]	[-0.07437]	[-0.73337]
LNCPI(-2)	-0.564957	-1.589359	-0.273898	0.165818	-0.859178	0.004707
	(0.62524)	(1.65414)	(0.14272)	(1.53647)	(1.62082)	(0.00459)
	[-0.90359]	[-0.96084]	[-1.91908]	[0.10792]	[-0.53009]	[1.02457]
LNAAR(-1)	0.088903	-0.235957	0.033549	-0.119990	0.229443	0.000604
	(0.06601)	(0.17463)	(0.01507)	(0.16221)	(0.17111)	(0.00049)
	[1.34689]	[-1.35120]	[2.22660]	[-0.73973]	[1.34090]	[1.24602]
LNAAR(-2)	0.120143	0.083568	0.059577	-0.108306	0.007926	0.001190
	(0.07328)	(0.19387)	(0.01673)	(0.18008)	(0.18996)	(0.00054)
	[1.63955]	[0.43106]	[3.56168]	[-0.60145]	[0.04172]	[2.20971]
LNFIV(-1)	0.146890	0.481962	-0.023625	0.252164	0.354477	-0.000227
	(0.07002)	(0.18524)	(0.01598)	(0.17206)	(0.18151)	(0.00051)
	[2.09790]	[2.60182]	[-1.47810]	[1.46553]	[1.95294]	[-0.44191]
LNFIV(-2)	-0.234572	-0.517797	-0.043699	0.318777	-0.199583	-0.002100
	(0.07650)	(0.20240)	(0.01746)	(0.18800)	(0.19832)	(0.00056)
	[-3.06617]	[-2.55829]	[-2.50228]	[1.69561]	[-1.00636]	[-3.73591]
LNPG(-1)	4.397032	-6.393455	5.838158	-35.66709	11.59568	1.822935
	(6.37703)	(16.8712)	(1.45569)	(15.6711)	(16.5314)	(0.04686)
	[0.68951]	[-0.37896]	[4.01057]	[-2.27598]	[0.70143]	[38.9035]
LNPG(-2)	1.527991	8.699318	-4.175405	29.76986	-0.373160	-0.860776
	(5.95163)	(15.7458)	(1.35859)	(14.6257)	(15.4286)	(0.04373)
	[0.25673]	[0.55249]	[-3.07334]	[2.03545]	[-0.02419]	[-19.6830]
C	-57.09542	-21.56729	-16.73817	68.24213	-109.0442	0.325364
	(17.9046)	(47.3688)	(4.08711)	(43.9993)	(46.4147)	(0.13156)
	[-3.18887]	[-0.45531]	[-4.09536]	[1.55098]	[-2.34935]	[2.47309]
R-squared	0.997982	0.982175	0.999787	0.548631	0.992802	0.999996
Adj. R-squared	0.996882	0.972452	0.999671	0.302429	0.988876	0.999994
Sum sq. resids	0.069386	0.485658	0.003616	0.419022	0.466289	3.75E-06
S.E. equation	0.056160	0.148578	0.012820	0.138009	0.145585	0.000413
F-statistic	906.8056	101.0160	8613.787	2.228383	252.8599	473379.8
Log likelihood	59.24689	25.19514	110.9496	27.77782	25.90736	231.2138
Akaike AIC	-2.642680	-0.696865	-5.597120	-0.844447	-0.737563	-12.46936
Schwarz SC	-2.064979	-0.119164	-5.019419	-0.266746	-0.159863	-11.89166
Mean dependent	11.02903	8.743379	4.077658	6.108118	9.495147	10.71990
S.D. dependent	1.005709	0.895170	0.706922	0.165239	1.380309	0.168673

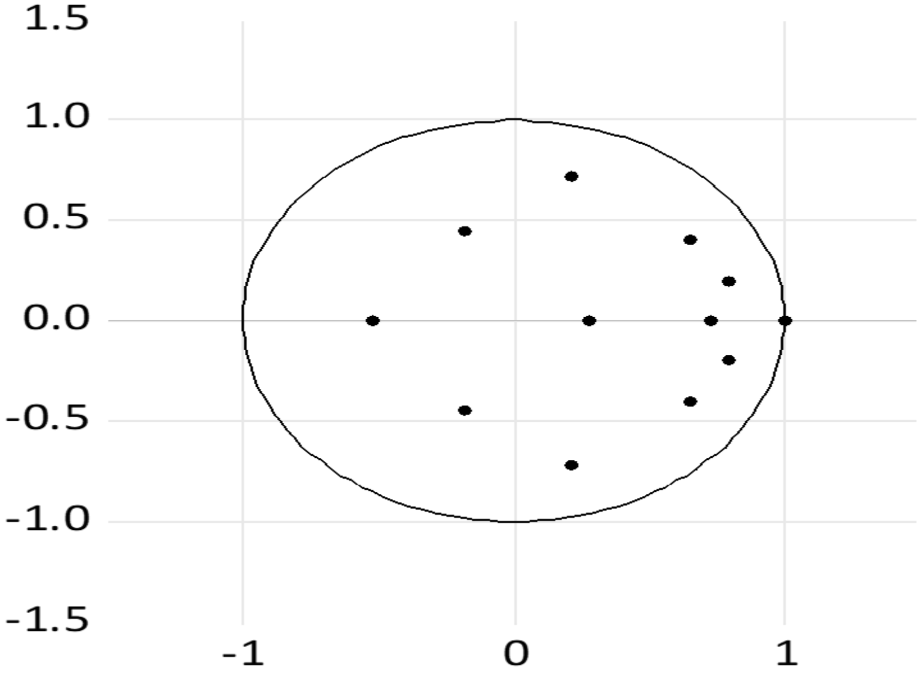
Determinant resid covariance (dof adj.)	1.80E-19
Determinant resid covariance	1.11E-20
Log likelihood	506.0803
Akaike information criterion	-24.46173
Schwarz criterion	-20.99553
Number of coefficients	78

APPENDIX 8: STABILITY TEST RESULTS

Roots of Characteristic Polynomial
Endogenous variables: LNVAP LNGEA
LNCPI LNAAR LNFIV LNPG
Exogenous variables: C
Lag specification: 1 2
Date: 02/21/22 Time: 16:39

Root	Modulus
0.999311	0.999311
0.788846 - 0.194580i	0.812490
0.788846 + 0.194580i	0.812490
0.652225 - 0.407129i	0.768864
0.652225 + 0.407129i	0.768864
0.213037 - 0.719717i	0.750585
0.213037 + 0.719717i	0.750585
0.724670	0.724670
-0.522612	0.522612
-0.176970 - 0.446576i	0.480363
-0.176970 + 0.446576i	0.480363
0.277539	0.277539

No root lies outside the unit circle.
VAR satisfies the stability condition.



APPENDIX 9: AUTOCORRELATION RESULTS

System Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Date: 12/12/21 Time: 01:12
Sample: 1985 2019
Included observations: 35

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	32.41480	0.6399	33.36818	0.5944	36
2	67.29024	0.6351	70.35728	0.5328	72
3	99.21200	0.7154	105.2717	0.5564	108
4	141.1624	0.5513	152.6351	0.2953	144
5	165.2624	0.7775	180.7518	0.4702	180
6	201.9443	0.7451	225.0230	0.3227	216
7	219.0128	0.9343	246.3586	0.5884	252
8	242.5154	0.9760	276.8250	0.6714	288
9	268.8734	0.9886	312.3068	0.6696	324
10	298.2606	0.9923	353.4489	0.5874	360
11	317.0200	0.9986	380.8063	0.6996	396
12	348.1969	0.9988	428.2495	0.5419	432

*The test is valid only for lags larger than the System lag order.
df is degrees of freedom for (approximate) chi-square distribution
*df and Prob. may not be valid for models with lagged endogenous va...

APPENDIX 10: HETEROSCEDASTICITY TEST RESULTS

VAR Residual Heteroskedasticity Tests (Levels and Squares)
Date: 02/21/22 Time: 16:27
Sample: 1983 2019
Included observations: 35

Joint test:

Chi-sq	df	Prob.
525.1318	504	0.2491

Individual components:

Dependent	R-squared	F(24,10)	Prob.	Chi-sq(24)	Prob.
res1*res1	0.550876	0.511066	0.9136	19.28067	0.7369
res2*res2	0.896603	3.613121	0.0194	31.38112	0.1431
res3*res3	0.632086	0.715843	0.7596	22.12299	0.5719
res4*res4	0.853664	2.430666	0.0724	29.87825	0.1888
res5*res5	0.758568	1.309149	0.3391	26.54989	0.3259
res6*res6	0.810814	1.785753	0.1704	28.37849	0.2444
res2*res1	0.798966	1.655952	0.2049	27.96381	0.2616
res3*res1	0.624747	0.693694	0.7780	21.86613	0.5873
res3*res2	0.739617	1.183538	0.4074	25.88658	0.3589
res4*res1	0.725130	1.099203	0.4602	25.37956	0.3854
res4*res2	0.588160	0.595052	0.8563	20.58558	0.6630
res4*res3	0.841590	2.213636	0.0955	29.45565	0.2035
res5*res1	0.843626	2.247884	0.0914	29.52691	0.2009
res5*res2	0.903417	3.897421	0.0148	31.61960	0.1367
res5*res3	0.803871	1.707784	0.1903	28.13548	0.2544
res5*res4	0.774908	1.434428	0.2823	27.12178	0.2988
res6*res1	0.437260	0.323758	0.9886	15.30409	0.9115
res6*res2	0.839508	2.179519	0.0999	29.38278	0.2061
res6*res3	0.571103	0.554817	0.8851	19.98860	0.6974
res6*res4	0.762472	1.337509	0.3253	26.68651	0.3193
res6*res5	0.863823	2.643085	0.0559	30.23382	0.1771

APPENDIX 11: NORMALITY RESULTS

VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: Residuals are multivariate normal
Date: 12/12/21 Time: 01:15
Sample: 1983 2019
Included observations: 35

Component	Skewness	Chi-sq	df	Prob.*
1	0.681677	2.710656	1	0.0997
2	0.439981	1.129235	1	0.2879
3	-0.026239	0.004016	1	0.9495
4	0.354811	0.734363	1	0.3915
5	0.300509	0.526782	1	0.4680
6	0.235003	0.322153	1	0.5703
Joint		5.427206	6	0.4903

Component	Kurtosis	Chi-sq	df	Prob.
1	2.529783	0.322443	1	0.5701
2	3.268545	0.105170	1	0.7457
3	2.466333	0.415335	1	0.5193
4	2.530958	0.320835	1	0.5711
5	4.046593	1.597395	1	0.2063
6	2.489641	0.379847	1	0.5377
Joint		3.141024	6	0.7910

Component	Jarque-Bera	df	Prob.
1	3.033099	2	0.2195
2	1.234405	2	0.5395
3	0.419351	2	0.8108
4	1.055198	2	0.5900
5	2.124177	2	0.3457
6	0.702001	2	0.7040
Joint	8.568230	12	0.7393

*Approximate p-values do not account for coefficient estimation