

**Population Growth and Food Production in Nigeria**

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Degree (MSc) in Economics**

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### Certification

This is to certify that Ifetolase Dorcas, OJENIYI with Matriculation Number LCU/PG/001478 carried out this research work titled “Food Production and Population Growth in Nigeria” in the Department of Economics, Faculty of Management and Social Sciences, Lead City University, Ibadan, Oyo State Nigeria, for the award of Master’s Degree (MSc) in Economics and that this has not been previously submitted.

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## **Dedication**

This thesis is dedicated to the Almighty God, the one who gives me hope and courage at all times.

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Even though the above-mentioned institution and persons have assisted in this research work. I alone stand responsible for errors, if any, found in the work.

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## Abstract

This study explored the interrelationships between population growth and food production in Nigeria. The objectives were to analyze the asymmetric causal relationship between population growth and food production, examine the asymmetric effect of population growth on food production and assess the response of food production to shocks in population growth in Nigeria. These were estimated using secondary time series data from 1981 to 2021 which was subjected to statistical estimations. The study adopted the asymmetry causality test based on Toda Yamamoto method, nonlinear ARDL (NARDL) and impulse response function and variance decomposition. The findings reveal that population growth and food production in Nigeria exhibit a significant bi-directional causal relationship. Positive and negative population growth both revealed a one-way causality on food production. The labor force participation rate is also positively correlated with agricultural output, indicating that a larger labor force engaged in agriculture leads to higher productivity. The short-run asymmetric estimates demonstrate that positive population growth has a negative impact on agricultural output, while lagged positive and negative population growth have positive effects. In the long run, deposit money bank credit to agriculture and government expenditure as a percentage of GDP show marginally significant effects on food production. Shocks in population growth, labor force participation rate, government expenditure, deposit money bank credit to agriculture, inflation rate, and exchange rate have varying effects on food production in Nigeria. The study concludes that population growth has a significant impact on food production, both positively and negatively, emphasizing the need for sustainable population management strategies. The labor force participation rate and other macroeconomic indicators also play crucial roles in influencing food production. It was recommended that policymakers should implement strategies that promote agricultural output and maintain stable population growth.

**Keywords:** Population Growth, Food Production, Agricultural Output, Labour Force Participation.

**Word Count:** 287

## Table of Content

Content	Page
Title Page	i
Certification	ii
Dedication	iii
Acknowledgement	iv
Abstract	vi
Table of Content	vii
List of Tables	ix
List of Figures	x
<b>Chapter One: Introduction</b>	<b>1</b>
1.1 Background to the Study	1
1.2 Statement of the Problem	5
1.3 Research Questions	8
1.4 Objectives of the Study	8
1.5 Research Hypothesis	8
1.6 Significance of the Study	9
1.7 Scope of the Study	9

1.8	Operational Definition of Terms	
10		
	Endnotes	11
	<b>Chapter Two: Literature Review</b>	13
2.1	Conceptual Review	13
2.1.1	Population Growth	13
2.1.2	Food Production	16
2.2	Theoretical Framework	22
2.2.1	Malthusian Theory	22
2.2.2	The Classical Growth Theory	24
2.2.3	The Theory of Optimum Population	25
2.2.4	The Neo- Classical Theory	26
2.3	Review of Empirical studies	27
2.4	Theoretical Framework	32
2.4	Gaps in Literature Review	31
	Endnotes	34
	<b>Chapter Three: Methodology</b>	43
3.1	Model Specification	
43		
3.1.1	Model of the Asymmetric Causal Relationship Between Population Growth and Food Production in Nigeria.	44
3.1.2	Model of the Asymmetric Effect of Population Growth on Food Production in Nigeria.	46
3.1.3	Model for the accessing the response of food production to shocks in population growth in Nigeria.	48
3.2	Data Measurement and Description of Variable	
48		

3.3	Data Requirement and Sources	
49		
3.4	Estimation Procedure	
49		
	Endnotes	52
	<b>Chapter Four: Results and Discussion of Findings</b>	
53		
4.1	Preliminary Analysis	53
4.1.1	Presentation of Data	53
4.1.2	Graphical Trend Analysis of Variables	54
4.1.3	Descriptive Statistics of Variables	57
4.2	Pre-Estimation Test	60
4.2.1	Correlation Analysis	61
4.2.2	Unit Root Test	62
4.3	Analysis of the Asymmetric Causal Relationship Between Population Growth and Food Production in Nigeria.	63
4.4	Examination of the Asymmetric Effect of Population Growth on Food Production in Nigeria.	68
4.5	Analysis Result of the Assessment of the Response of Food Production to Shocks in Population Growth in Nigeria	75
4.6	Discussion of Findings	
81		
	Endnotes	87
	<b>Chapter Five: Conclusion</b>	90
5.1	Summary of Findings	
90		
5.2	Conclusion	
94		

5.3	Recommendations	
95		
5.4	Contribution to Knowledge	
97		
5.5	Area of Further Research	
97		
	Bibliography	99
	Appendices	
111		
	Bio data	
137		
	The University Compliance Certification	
139		

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## List of Tables

Table	Title	Page
3.1:	Description Measurement of the Variables in the Study	49
4.1:	Descriptive Statistics	58
4.2	Correlation Matrix	
61		
4.3	Summary of the ADF Test	
63		
4.4	Lag Order Selection	
64		
4.5:	Autocorrelation LM Test	65
4.6	Asymmetric Causality Results based on TY Procedure	
65		
4.7	Asymmetric Cointegration Test Results using NARDL Bound Test	
68		
4.8:	Short run and Long run Asymmetric Effect of Population Growth on Food Production in Nigeria.	
69		
4.9	Result of Variance Decomposition Analysis	
78		

## List of Figures

Figure	Title	Page
4.1:	Trend Analysis of Agricultural Output as a Percentage of GDP (AGDP), Growth of Population (POPG) and Deposit Money Bank Credit to Agriculture (DCA)	54
4.2:	Trend Analysis of Agricultural Output as a Percentage of GDP (AGDP), Growth of Population (POPG) and Labour Force Participation (LFP)	56
4.3:	Trend Analysis of Agricultural Output as a Percentage of GDP (AGDP), Growth of Population (POPG) and Government Expenditure as a Percentage of GDP (GE)	56
4.5	Asymmetric Cumulative Dynamic Multiplier	74
4.6:	Impulse Response Function Graph of Food Production to Population Growth Shocks	76

## **Chapter One**

### **Introduction**

#### **1.1 Background to the Study**

Food is no doubt, an important requirement for human survival. Production of food depends on agricultural outputs in the society. Globally, agricultural outputs will need to increase by an estimated 70 percent by 2050 to ensure an adequate food supply<sup>1</sup>. The situation of food production in Nigeria has been a subject of concern for several years. Despite being a major producer of agricultural commodities, the country has been experiencing a decline in food production due to various factors such as climate change, inadequate infrastructure, poor storage facilities, and inadequate funding for the agricultural sector. Reports have shown that Nigeria's food production has been below its potential, and the country has been unable to meet the food demand of its rapidly growing population<sup>2</sup>. In recent years, Nigeria's food production has been on the rise. For instance, the country's cereal production increased from 34 million tons in 2014 to 44 million tons in 2018, representing a 29% increase. The production of root and tuber crops, such as cassava and yams, increased from 150 million tons in 2014 to 176 million tons in 2018, representing a 17% increase<sup>3</sup>.

With the population of Nigeria growing at an alarming rate, there has been pressure on the country's food production system. Nigeria's population was estimated to be over 206 million people in 2021, making it the seventh most populous country in the world. This rapid population growth has led to an increased demand for food, which the country has been unable to meet<sup>4</sup>. As a result, Nigeria has been experiencing food insecurity, with a large number of its citizens suffering from malnutrition. Scholars are of the opinion that Nigeria's agricultural sector has not been able to keep up with

the country's population growth, resulting in a decline in food production. It was further argued that inadequate funding, poor infrastructure, and inadequate policies have contributed to the decline in food production in the country<sup>5</sup>. Furthermore, according to a report by the United Nations Development Programme (UNDP), the rapid population growth in Nigeria has put pressure on the country's food production system, leading to food insecurity. The report notes that Nigeria's population is projected to reach over 400 million people by 2050, which will further exacerbate the food insecurity situation in the country.

Nigeria is blessed with a very diverse and rich vegetation capable of supporting large population of livestock and has estimated surface water volume of about 267.7 billion cubic meter and underground water of about 57.9 billion cubic meters. The ecological zones in Nigeria are also very diverse with the semi-arid Sudan (Sahel) zone, Guinea Savannah and Derived Savannah zone as well as Forest and Mangrove (high rainfall, moist sub-humid and very high humidity) zone. A few variations exist within each ecological zone. The ecology and trends in precipitation in a region determines what kind of farming system the people will practice, their food preference and how they make use of natural resources in their environment<sup>6,7</sup>.

Agriculture is at the center of the Nigerian economy, providing the main source of livelihood for the majority of Nigerians. The farming sector of this West African country employs about 70 percent of the entire country's labor force. Nigeria's small farms produce 80 percent of the total food and 33 percent of this country's land is under cultivation for this purpose<sup>8</sup>. Agriculture accounts for about 24 percent of Nigeria's GDP. The country is a leader in various types of agricultural production, such as palm oil, cocoa beans, pineapple, and sorghum. It is the largest producer of sorghum in the world just after the United States, and ranks fifth in the production of

palm oil and cocoa beans. Nigeria is also a large global exporter in this sector. Oil, fruits, nuts, seeds are among the ten best performing export categories<sup>9</sup>. For decades, Agriculture has been associated with production of essential food products which is the most important requirement for the survival of mankind. Agriculture therefore invented food production which is about preparing of food from its raw form to a consumable one either in the home or for industrial use.

In the 40s and early 50s, the agricultural system practiced ably sustained the population and have surplus to export. Different regions in Nigeria specialized in different kinds of crop production, whether food or cash crops and there was unity in the diversity. This system strengthened the country's food self-sufficiency<sup>10</sup>. The issue of food production is emerging as a major concern in national and international policy discourse. Globally, demand for more food and demand for more types of food are rising in response to changes in diet as well as population growth. Increasing wealth influences food consumption, as better-off families are able to spend more money on food and demand greater quantities of animal-based foods both of which require increased food production.

Food production in Nigeria has been a topic of concern because of its relationship with the growth of the economy and the country's increasing population. Nigeria being one of the world's largest producers of cassava, yams, and cowpeas, and the largest producer of tomatoes in sub-Saharan Africa still faces challenges in food production, distribution, accessibility and in achieving food security. In 2018, it was estimated that 22.2 million people were food insecure in Nigeria, representing 11% of the country's population<sup>3,4</sup>.

At the same time, projected world population growth from almost 7 billion in 2010 to 9.5 billion in 2050 a 36 percent increase means that total demand for food will

continue to rise, even independent of changing consumption patterns. United Nations, Department of Economic and Social Affairs projected that with the total fertility rate, or average number of children per woman, still high in the world's least-developed countries (approximately 4.5 children per woman in the 49 least-developed countries, according to the latest United Nations projection, for 2005–2010), population growth is fastest in places already suffering from the greatest food insecurity<sup>11</sup>.

In same vein, population growth in Nigeria is growing at 3.75% yearly, doubling its size every two decades, as rural - urban migration is growing due to many factors while this rapid population growth results in small or no per capita income except rural development<sup>12</sup>.

First to explicitly connect population growth with food production is the British Economist Thomas Malthus<sup>13</sup>. It is believed that there is a connection between food production and population growth, as a result, scholars have studied these relationships and found that population dynamics affects savings negatively, and this affects investment in the agricultural sector, leading to low agricultural output. It is this poor yield in agricultural produced, emanating from the dynamic nature of the population that resulted into food insecurity that characterized the Nigerian economy<sup>14</sup>.

However, the intensity of growth in population in developing nation like Nigeria is more severe than that of developed nations with 2.5 percent population growth rate according to world bank<sup>15</sup>. Technological, biological and Environmental factors affect the production of food in a country which is major treat to a developing nation in order to produce food at sufficiency or surplus rate.

Scholars have proposed food insufficiency as one of the threats that society will endure during this century as global population has grown exponentially. Current numbers are estimated around 6.7 billion and are expected to rise 9.3 billion in 2050<sup>16</sup>. The world population will keep growing and the demand for food should experience increase as well. Food demand is expected to increase anywhere between 59% to 98% by 2050<sup>17</sup>. This will shape agricultural markets in ways we have not seen before. Farmers worldwide will need to increase crop production, either by increasing the amount of agricultural land to grow crops or by enhancing productivity on existing agricultural lands through fertilizer and irrigation and adopting new methods like precision farming<sup>18</sup>. However, farmers Worldwide will need to increase crop production. Right now, crops harvested per unit of land cultivated are growing too slowly to meet the forecasted demand for food.

Studies from different countries also showed that international development has been feared to impose considerable challenges to global food production because there is a need for more food has to be produced with less or fewer agricultural resources. As population increases, demand for food increases, increasing population along with land degradation aggravates challenges of food production<sup>19</sup>. Hence, there is a need to investigate the growth between the two variables over years and the causal relationship between them. Hence, it is needed for carrying out this study.

## **1.2 Statement of the problem**

Studies have also identified priority areas in Africa as the continent have achieved unprecedented economic growth over the past two decades and is experiencing its longest period of sustained economic growth since the 1960s. The growth rate has not only accelerated, but also spread geographically. In 2015, average real Gross Domestic Product (GDP) grew by 3.5 percent, higher than the global average of 3.1

percent and the Eurozone average of 1.5 percent. Africa's rapid population growth, coupled with a changing global food landscape means that African agriculture must grow to feed the rising population, reduce its external food dependency, and ensure food security for its population<sup>20</sup>.

An assessment of the Food and Agriculture Organization of the United Nations (FAO) showed that around 795 million people in the world remained undernourished. This figure represents 167 million and 216 million reductions in the last decade and since 1990 respectively. As many Nigerian live in hunger, there seem to be no hope in the future as it has been projected that 19.4 million Nigerians are to face food insecurity by August 2022<sup>21,22</sup>.

Many Scholars have investigated food production from the perspective of food insecurity in Nigeria, squealing to the discovery of petroleum, Nigeria has rapidly grown into a major food importing nation as the government has become neglectful of the agricultural sector since petroleum is considered a more viable resource for economic development. This situation quickly polarized the nation into high- and low-income groups. Unfortunately, while only small fraction of the population benefited from the oil wealth, the population suffered the misfortune of food insecurity as they can hardly afford the rising prices of imported foods<sup>10,14</sup>.

However, though at a subsistence level, a sizable ratio of the population in Nigerian is still employed in the Agricultural sector. Providing nutritious and environmentally sustainable food to all people at all times is one of the greatest challenges currently facing the society. This problem is particularly acute in Africa, where an estimated one out of nine people still lack adequate and balanced diet to maintain active and healthy life. In Nigeria, a country of more than 216 million<sup>23</sup>. Is it possible for Nigeria

economy to experience zero hunger, availability and access to safe and nutritious food for all at local levels?

In northern Nigeria, the Boko haram insurgency has led to heightened levels of displacement and insufficient food production. Even as climate change also impact on the environment and farming communities, the effects of violence and conflict have dire. The farmers –herders clash is usually identified as one of the significant causes of insufficient food production in the country. Now, targeted attacks on farmers and farming communities by Boko haram insurgents and armed bandits may have increased the tempo of threats on Nigeria’s food production. While the food crisis in the terror-troubled northeast is increasing humanitarian emergencies in the region, attacks on the farmers leave less to be desired.

The pandemic and the recession are already worsening living conditions in Nigeria. Adding insufficient food production to the list will not only affect the vulnerable population, but will also create vulnerability for government and the society. Many farming communities are caught in the triangle of conflict, climate change and ineffectual policies that has not helped to control population growth.

Notwithstanding these issues, Nigeria’s population keeps growing and as a result, there is an increased demand for food, which has led to a decline in food security and a rise in food prices. The relationship between population growth and food production in Nigeria has not been fully understood, and the extent to which population growth affects food production remains unclear. Moreover, it is unknown how food production responds to shocks in population growth. Therefore, this study seek to investigate the causal relationship between population growth and food production in Nigeria, the extent to which population growth affects food production, and how food production responds to shocks in population growth.

### **1.3 Research Questions**

The research questions drawn for the purpose of this study include;

1. What Asymmetric causal relationship exist between population growth and food production in Nigeria?
2. To what extent does population growth affect food production in Nigeria?
3. How does food production respond to shocks in population growth in Nigeria?

### **1.4 Objectives of the Study**

The broad objective of this study is to investigate the nexus existing between population growth and food production in Nigeria between 1981 and 2021. The specific objectives of the study are to:

1. Analyze the asymmetric causal relationship between population growth and food production in Nigeria.
2. Examine the asymmetric effect of population growth on food production in Nigeria.
3. Assess the response of food production to shocks in population growth in Nigeria.

### **1.5 Research Hypothesis**

This study seeks to test the following hypothesis:

H01: There is no significant asymmetric causal relationship between population growth and food production in Nigeria

H02: There is no significant effect of population growth on food production in Nigeria

H03: There is no response of food production to shocks in population growth in Nigeria

### **1.6 Significance of the Study**

The aim of the study is to contribute to the existing body of knowledge on the relationship between food production and population growth in Nigeria. With increasing number of people driving up the demand for food which typically results in more use of arable land and water for more food production, every one out of ten around the globe are chronically hungry as a result of lack of food/water, sufficient food/ water or right combination of food/water. Looking into food production in relationship to population growth in developing countries such as Nigeria can improve its economic growth and provide a deep cognizant into providing adequate food demand and supply.

The findings of the study will also measure factors that slow down food production. The possibility of optimizing food consumption per capita, each additional person would increase its nutritional needs and in turn cause increase in total food demand. The study is also significant to both local and international investors that are looking into Nigeria food production. Nigeria's food crisis may be lurking at a distance but without an urgent and comprehensive series of intervention, the entire nation will be facing the consequences of full-blown shortage of food production.

### **1.7 Scope of the Study**

The objective of this study is to examine the relationship between food production and population growth in Nigeria using annual data from 1981-2021. These period

has a trend of decline in the prevalence of food insecurity and menace of food insecurity, starting with the introduction of the structural adjustment program in 1986.

### **1.8 Operational Definition of Terms**

**Food Production:** it is about preparing food, in which raw materials are converted into ready-made food products for human use either in the home or in the food processing industries.

**Food Security:** it is the state of being with reliable access to a sufficient quantity of affordable, nutritious food.

**Population Growth:** population growth is the increase in the number of humans on earth.

**Asymmetric Effect:** An asymmetric effect refers to a situation where the impact or influence of a particular factor or variable is not equal in all directions or under all circumstances.

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## **Chapter Two**

### **Literature Review**

#### **2.0 Preamble**

This chapter presents a review of past literature by discussing the concepts of the study, the relevant theories and empirical findings of literature as related to population growth and food production. The framework of the study was also presented as well as the summary of gaps found in literature.

#### **2.1 Conceptual Review**

This section defines and discuss the fundamental terms of population, population growth, population growth rate, agricultural production, and food security.

##### **2.1.1 Population Growth**

Population refers to the numbers of people inhabiting in a particular area in a particular time. Population is also described as the total number of beings living in a particular area. It is also a count of the number of residents within a political or geographical boundary such as a town, a nation or the world<sup>1</sup>. Members of a population frequently rely on the same resources, face comparable environmental restrictions, and rely on the availability of other members to survive. Knowing the population of a particular geographical area, help in estimating the amount of resources that is necessary for their basic needs. As the resources are limited, the ever-increasing population which makes decision making challenging.

Population Growth is an increase in the population of a country. It refers to growth in the number of people in a geographical location..population growth can be a useful factor in providing a workforce for the production of goods and services to boost economic development, and remains a critical determinant of the potential of a

country's investment. However, increase in population alone may not increase poverty incidence in a country, considering the development in China, and other countries, that have noticed considerable economic growth over the last decades despite their large population size<sup>1,2</sup>.

Population Growth Rates are the annual changes in population caused by births, deaths, and net migration. National military forces stationed abroad; commercial seafarers at sea; diplomatic staff stationed abroad; civilian immigrants' resident in the country; displaced persons' resident in the country comprise the total population. It does, however, preclude the following: foreign armed forces stationed in the country; foreign diplomatic staff stationed in the country; and civilian immigrants visiting the country temporarily<sup>3</sup>. The rate of population growth has been a critical for the development of any economy and where if not properly managed, could inflate the scourge of poverty in the economy.

In some ways, population is a source of labour that could be used to improve the country's output. It broadly refers to all nationals who are present in, or temporarily absent from, a country, as well as aliens who are permanently settled in a country. Rising population growth puts intense pressure on resources of a Nation. It affects national income as government has to devote substantial resources to feed the growing population. It affects food supply, depletes the environment, results to urbanization, migration, unemployment and scarcity of several other resources.

As the world's population is rapidly growing, this growth is seen in Africa and Nigeria as Africa remains the world's second largest continent after Asia, with a population which increased from 221 million people in 1950 to 888 million people in 2005 and 1 billion in 2009 and Nigeria being the most populous nation in Africa. Statistics shows that Nigeria's annual population increased considerably with time,

from 75.5 million people in 1980 to 122 million people in 2000, which increased to 159 million in 2010 and to 162.5 million people in 2011. The population had been growing at the rate of 2.8% per annum in the decade preceding year 2000 and beyond before increasing to 3.2% in 2008 to 2012 and then falling marginally to the current levels of 3.1%, while it has been estimated at 233 million by 2020, and 389.615 million by 2050<sup>4,5</sup>. Nigeria remains the most populated black nation in the world with enviable wealth from crude petroleum, providing a great market and investment potentials for different economic activities, which can be harnessed by other economies of the world. However, the country faces numerous socioeconomic problems including; poverty, corruption, hunger and social unrest, alongside continuously increasing population growth<sup>5</sup>.

Meanwhile, measures to address food sufficiency in Nigeria therefore must focus on the need to enhance the income generating capacity of government so as to be in a good standing to provide food and other basic infrastructure for the populace in addition to checking the rapid population explosion.

Major determinants of Population Growth in Nigeria includes the following:

- i. Refugees and asylum seekers
- ii. Birth rate
- iii. Death rate
- iv. Infant mortality rate
- v. Fertility rate
- vi. Migration rate
- vii. Life expectancy at birth

The growth of the population in Nigeria is influenced by the number of refugees and asylum seekers. In 2014, 941 people sought asylum, and with the addition of refugees, the number rose to 2620. Birth rate, death rate, infant mortality rate, fertility rate, migration and life expectancy at birth also determine population growth. Birth rate has remained high at 38.4 per 1000 people, with a gradual decrease from 42.5 in 2005. Death rate has been decreasing, with a rate of 12.5 per 1000 people in 2016. Infant mortality rate has fallen, with 74.5 deaths per 1000 live births in 2017 for males and 64.8 for females. Fertility rate has fallen only slightly, with 5.46 births per woman in 2017. Life expectancy at birth was 53.88 years in 2017, increasing at an average annual rate of 0.84%. Migration rate was -0.35 migrants per 1000 population in 2015, peaking at -0.2 in 2017. A lower death rate and infant mortality rate leads to higher population growth, while higher fertility rate, birth rate, migration rate, and life expectancy at birth result in higher population growth<sup>3</sup>.

### **2.1.2 Food Production**

Agriculture is the science and industry of managing the growth of plants and animals. In a broad sense, agriculture includes cultivation of the soil, growing and harvesting crops, breeding and raising livestock, dairying and forestry<sup>6</sup>. It involves the cultivation of land, raising and rearing of animals, for the purpose of production of food for man, feed for animals and raw materials for industries. It involves cropping, livestock, forestry, fishing, processing and marketing of these agricultural products. Agriculture is divided into four sections which are fishing, crops, livestock and forestry.

Scholars generally use agricultural output/productivity to measure food production in an economy. Some researchers have estimated agricultural productivity using the ratio of agricultural outputs to inputs. It includes animal enterprise output, crop enterprise

output, by-products, fodder and cultivation, and other output that covers the monetary worth of output from those agricultural activities but is not livestock or crop enterprise output. The link between agricultural outputs and agricultural inputs is used to calculate agricultural output. Agricultural output is the entire value of output from crop cultivation, livestock, forestry, and fishing in an economy. Agriculture's main product categories are livestock and crops. Agricultural output consists of the following components: output sold (including trading across agricultural holdings); stock fluctuations; production for own final consumption; output produced for further processing by agricultural producers; and intra-unit consumption of livestock feed products<sup>3,7</sup>.

Agriculture is both the main traditional pursuit and key to sustained growth of the modern economy. Economic growth has gone hand in hand with agricultural progress; stagnation in agriculture is the principal explanation for poor economic performance, while rising agricultural productivity has been the most important concomitant of successful industrialization. Among the roles conventionally ascribed to the agricultural sector in a growing economy are those of providing adequate food for an increasing population, supplying raw materials to a growing industrial sector, constituting the major source of employment, earning foreign exchange through commodity exports, and providing markets for the products of the industrial sector.

Nigeria relies on \$10 billion of imports to meet its food and agricultural production shortfalls (mostly wheat, rice, poultry, fish, food services, and consumer-oriented foods). Europe, Asia, the United States, South America, and South Africa are major sources for agricultural imports. The Government of Nigeria has initiated agricultural programs such as the Anchor Borrowers Program (ABP) to diversify its economy away from oil. GON at the Council on Agriculture and Rural Development Regular

meeting, approved the implementation of new Agricultural policy named “National Agricultural Technology and Innovation Plan” (NATIP). The four-year blueprint designed to help Nigeria’s COVID-19 economic recovery. This policy will replace the Agriculture Promotion Policy (APP) that was launched in 2016 but terminated in December 2020<sup>8</sup>.

The agriculture sector in Nigeria has been impacted by several factors such as flooding, Boko Haram insurgency and conflicts between herdsmen and farmers, which have hurt food production. To improve food production, various strategies have been proposed such as increasing farmers access to agricultural finance to increase productivity, and promoting agricultural diversity. Agriculture represents a crucial part of Nigeria's economy, contributing over 80% of the total industry size. Despite its significance, the sector's contribution to GDP has declined from 31% in 2013 to 78 billion USD in 2017<sup>9,10</sup>.

Low food production is a major issue in Africa, with over 50% of the population relying on subsistence farming. The agriculture sector plays a vital role in the African economy, accounting for over 40% of GDP and employing 65-70% of the population. The food economy, which includes all aspects of food production, processing, packaging, transportation, and retailing, employs 85 million people in Nigeria, with 75% of food economy employment in agriculture. However, food production has declined, leading to an increase in food imports, with food import expenditure estimated to increase to 110 billion USD by 2025<sup>11,9</sup>.

To control food importation and increase local food production, the Nigerian government has implemented programs such as the Agricultural Transformation Agenda, Anchor Borrowers, Commercial Agriculture Credit Scheme, and Agricultural Credit Guarantee Scheme Fund, among others. Despite these efforts,

agricultural financing has declined in Nigeria, with the ratio of the agriculture budget to the national budget below the standard set by the Maputo Declaration on Agriculture and Food Security. In addition, credit to agriculture has declined from 83.20 in 2013 to 40.62 in 2015. The government must take steps to improve agricultural financing and support the agriculture sector to increase food production and reduce reliance on imports<sup>12</sup>.

Food security refers to the availability, accessibility, and affordability of food to meet the nutritional needs of individuals and households. This is a major global challenge, with nearly 100 million people unable to access sufficient food and over 400 million suffering from chronic malnutrition. The absence of one or more components of the food systems, including institutions, practices, and technology that control food production, processing, distribution, retailing, and consumption, leads to food insecurity<sup>13, 14</sup>.

Nigeria, once a major food exporter, has transformed into a major food importer, with the government spending N218 billion on food importation in 2014. This transformation has been attributed to various reasons, including rapid population growth, poor policies, and the "Dutch disease"<sup>15</sup>. The government has taken action to address this issue by implementing programs such as Operation Feed the Nation, the Agricultural Development Project, and the National Fadama Development Project. However, these programs have fallen short due to corruption in Nigeria<sup>16</sup>.

Food and nutrition security involves providing energy, protein, and essential nutrients for a healthy lifestyle. The World Health Organization recommends an intake of 2500–3400Kcal of energy per person per day and 65-86g of crude proteins per day, with at least 40% of protein from animal sources<sup>10</sup>. Despite the efforts made by the government and other organizations, food insecurity remains a major issue in many

low-income countries, with sub-Saharan Africa and South Asia being the regions with high levels of human malnutrition<sup>17</sup>.

Food insecurity is linked to poverty, hunger, and malnutrition. Hunger is a state of distress caused by a lack of food, while malnutrition refers to an abnormal physiological condition caused by inadequate intake or absorption of essential nutrients. Poverty refers to several levels of deprivation related to human capabilities, including consumption, health, education, rights, security, and decent work. The poverty rate is defined as the ratio of people with income below the poverty line to half the total population median household income<sup>18, 6, 8</sup>.

From 2013 to 2017, food prices rose from 9.3% to 19.4%, hindering food supply efforts and leading to escalating food prices. Agricultural production encompasses food, fuels, and raw materials, with cereals, vegetables, fruits, oils, meats, and spices being some of the major food products<sup>19</sup>. The poverty rate in Nigeria is high, with an estimated 74.1% of the rural population and 25.9% of the urban population living in poverty in 2010, and rural areas having a higher poverty rate than urban areas<sup>20</sup>.

Food insecurity is a serious issue in many low-income countries, affecting one out of seven people on the planet. Despite the efforts made by the government and other organizations, food insecurity remains a global threat, with 11 million children under the age of five dying from hunger and hunger-related diseases annually. Improving self-sufficiency, affordability, and availability are crucial policies to achieve food security<sup>21, 22</sup>.

### **Limitations of Food Production in Nigeria**

Natural Disasters and Climate Change: One of the major challenges affecting food production in Nigeria is the impact of natural disasters and climate change. Nigeria is

susceptible to frequent droughts, floods, and heat waves that can damage crops, cause soil degradation and reduce agricultural yields. Climate change has also led to unpredictable weather patterns that make it difficult for farmers to make informed decisions about what and when to plant. The loss of fertile land and soil degradation as a result of environmental degradation and poor agricultural practices exacerbates this challenge<sup>22</sup>.

**Infrastructure Deficiencies:** Infrastructure deficiencies also pose a significant challenge to food production in Nigeria. The country lacks adequate transportation networks and storage facilities, making it difficult to get crops from the farm to the market and keep them fresh during transportation. The absence of proper storage facilities and refrigeration equipment also leads to significant food waste, further reducing the availability of food. The inadequate rural electrification also limits the use of modern agricultural technologies and reduces the productivity of farmers<sup>19,23</sup>.

**Access to Inputs and Financial Resources:** Another key challenge affecting food production in Nigeria is limited access to inputs and financial resources. Many farmers struggle to acquire the necessary inputs such as seeds, fertilizers, and pesticides, and lack the financial resources to invest in their farms. This leads to low yields and reduced profits, discouraging farmers from continuing with agricultural activities. The lack of access to credit also limits the ability of farmers to adopt new technologies and improve their farming methods<sup>18,17</sup>.

**Pest and Disease Outbreaks:** Pest and disease outbreaks are also major challenges facing food production in Nigeria. The spread of pests and diseases such as the fall armyworm, cassava mosaic disease, and tomato leaf miner, among others, can lead to significant crop losses and reduce yields. The absence of effective pest and disease

control measures and inadequate research and development efforts to address these challenges exacerbates the situation<sup>23</sup>.

**Political Instability and Corruption:** Political instability and corruption also pose significant challenges to food production in Nigeria. The lack of stable and predictable policies, regulatory frameworks, and legal systems creates a hostile environment for investment and growth in the agricultural sector. Corruption in the distribution of subsidies and input supplies also leads to misallocation of resources, reducing their impact on food production. Additionally, the unequal distribution of land ownership and access to resources among different groups in Nigeria also creates a challenging environment for food production and exacerbates food insecurity<sup>23</sup>.

## **2.2 Theoretical Review**

### **2.2.1 Malthusian Theory**

The relationship between food production and food supply was first expressed by an English Economist called Thomas Robert Malthus (1798-1823). Malthus stated that population increased in a geometric progression (i.e., 2, 4, 16, 132...) while food production increased in arithmetic progression (i.e., 2, 4, 6, 8...) <sup>24, 25</sup>. Thus, population grew faster than food production and tended to outstrip it in a short time. He wrote, unless humans can limit reproduction voluntarily through self-restraint, population would be reduced by catastrophic events such as diseases, starvation, misery and wars. It was believed that a balance between population growth and food supply can be established through preventive and positive checks<sup>26</sup>.

### **Checks on Population**

When the increasing population rate is greater than the food supply, disequilibrium exists. As a result, people will not get enough food even for survival. People will die

due to a lack of food supply. Adversities such as epidemics, wars, starvation, famines and other natural calamities will crop up which are named as positive checks by Malthus. On the contrary, there are man-made checks known as preventive checks<sup>24</sup>.

### **Positive Checks**

Nature has its own ways of keeping a check on the increasing population. It brings the population level to the level of the available food supply. The positive checks include famines, earthquakes, floods, epidemics, wars, etc. Nature plays up when the population growth goes out of hand<sup>24</sup>.

### **Preventive Checks**

Preventive measures such as late marriage, self-control, and simple living, help to balance the population growth and food supply. These measures not only check the population growth, but can also prevent the catastrophic effects of the positive checks.

The Malthusian Trap (or “Malthusian Population Trap”) is the idea that higher levels of food production created by more advanced agricultural techniques create higher population levels, which then lead to food shortages because the higher population needs to live on land that would have previously used to grow crops. Even as technological advancement would normally lead to per capita income gains, theorizes Malthus, these gains are not achieved because in practice the advancement also creates population growth. Once the population exceeds what food supplies can support, this supposedly creates a Malthusian crisis with widespread famine as well as rampant disease. This ends up decreasing the population to earlier levels. The reality, however, has been that population growth has not itself created the crisis that Malthus predicted<sup>27,28</sup>.

## Criticism of Malthusian Theory of Population

The Malthusian theory was criticized based on the following:

1. **Population Growth:** The gloom and doom forecasts put forward by Malthus have not played out. In Western Europe, populations have grown (not at the rate Malthus predicted) and food production has also risen because of technological advancements.
2. **Food Production:** Thanks to many technological advancements, food production has dramatically increased over the past century. Often, the food production rate has grown higher than the population growth rate. For example, during the 1930s in the US, 25% of the population worked in the agricultural sector while the total GDP was less than \$100 billion. Today, less than 2% of the population works in the agricultural sector, while the total GDP is over \$14 trillion.
3. **Global Trade:** The limited availability of land at the time was the basis for Malthus' theory on food production constraints. However, thanks to globalization, we can trade goods and services for food, which increases the amount of food a country can consume.
4. **Calculations:** Malthus did not provide calculations for the geometric growth of populations and the arithmetic growth of food. Since then, experts have pointed out that the growth rates are not consistent with Malthus' predictions<sup>29,30,31</sup>.

### 2.2.2 The Classical Growth Theory

The classical growth theory is a major paradigm in the field of economics, developed in the late 18th and early 19th centuries. It is centered on the idea that the economy is self-sustaining and will naturally grow, provided that certain conditions are met, such

as a well-functioning market system and an efficient allocation of resources. The theory was first popularized by Adam Smith and later refined by Thomas Malthus and David Ricardo<sup>32</sup>. According to the theory, economic growth is driven by increases in labor and capital inputs, which result in increased output. The key contribution of classical growth theory was the insight that sustained economic growth requires not just a supply of capital and labor, but also the development of technological advances, which increase productivity and efficiency<sup>31, 33</sup>. In addition, the theory emphasized the importance of economic institutions and the role they play in promoting economic growth. The classical growth theory continues to be influential in the development of economic thought and remains a cornerstone of modern economic analysis.

The fundamental principle of the classical theory is that the economy is self-regulating. Classical economists maintain that the economy is always capable of achieving the natural level of real GDP or output, which is the level of real GDP that is obtained when the economy's resources are *fully employed*. While circumstances arise from time to time that cause the economy to fall below or to exceed the natural level of real GDP, self-adjustment mechanisms exist within the market system that work to bring the economy back to the natural level of real GDP. The classical doctrine that the economy is always at or near the natural level of real GDP is based on two firmly held beliefs: Say's Law and the belief that prices, wages, and interest rates are flexible<sup>34, 35</sup>.

### **2.2.3 The Theory of Optimum Population**

The Optimum Theory of Population is a major contribution to the field of demography and population studies. It was first proposed by Thomas Robert Malthus in 1798, and later developed by David Ricardo, John Stuart Mill, and Thomas Hill Green<sup>36, 37</sup>. The theory states that there is an ideal population size for a society, beyond

which population growth becomes negative and detrimental to economic and social development<sup>38</sup>.

The Optimum Theory of Population holds that population growth should not be unchecked, as this will lead to overpopulation and result in reduced living standards, unemployment, and poverty. On the other hand, a population decline will lead to a lack of workers, reduced economic growth, and reduced social welfare. The theory postulates that there is an optimal balance between population size and economic development, where the economy is able to provide for the needs of the population, and the population is able to contribute to the economy through productive labor<sup>30</sup>.

The Optimum Theory of Population has been a subject of much debate and discussion among economists, demographers, and policymakers. While it remains a valuable contribution to the field of population studies, it is often criticized for being too simplistic and failing to account for the complexities of population dynamics. Despite its limitations, the Optimum Theory of Population continues to influence thinking and policymaking in the areas of population and development<sup>37</sup>.

#### **2.2.4 The Neo- Classical Theory**

The Neo-Classical Growth Theory is a theoretical framework in economics that explains the relationship between economic growth and the accumulation of factors of production, such as capital and labor. It was developed by a number of prominent economists including Robert Solow, Trevor Swan, and Paul Romer<sup>38, 39</sup>. The theory represents a revival of classical economic principles and emphasizes the role of technological progress and capital accumulation in driving economic growth<sup>39</sup>.

The key idea behind the Neo-Classical Growth Theory is that economic growth is a result of increases in the productive capacity of an economy. According to this theory,

economic growth is driven by increases in the efficiency of production, which is influenced by advances in technology and the accumulation of physical and human capital. The theory suggests that as an economy accumulates more capital, it becomes more productive and can produce more output with the same amount of labor and other inputs<sup>40</sup>. This leads to higher levels of output, income, and consumption, and a higher standard of living for the population.

The Neo-Classical Growth Theory has been widely accepted and has had a significant impact on economic policy. It has been used to inform policies aimed at promoting economic growth and development, including policies aimed at improving the business environment, encouraging technological innovation, and increasing the availability of capital. It has also been used to examine the relationship between population growth and economic growth, with some economists suggesting that population growth can have both positive and negative effects on economic growth<sup>41,42</sup>. Overall, the Neo-Classical Growth Theory continues to be a central component of modern macroeconomic theory and is widely used by policymakers and researchers to understand and explain the complexities of economic growth and development.

### **2.3 Empirical Review**

Malthusian Population Theory in Nigeria from 1982 -2012<sup>7</sup>. The study applied vector error correction model and the result shows that Population Growth has no significant impact on Economic Development in Nigeria. This is in line with the works of<sup>8</sup>. In other words, the Malthusian population theory is relevant when applied to the Nigeria economy. The study posited that population growth is detrimental to economic development it is tantamount to averring that overpopulation and poverty are correlated which portends danger. This combination is associated with increased vices,

disease and death. This could be attributed to so many reasons chief amongst which is economic backwardness that basically depicts the inadequacy of social welfare programmes, infrastructure or the wherewithal to support the existing population. Also, communal and religious laws further influence population growth contradicting the axiom of moral restraint as enunciated by Malthus. The effect of population on the economy in Nigeria is much more than the food problems enunciated by Malthus. Some of these consequences are congestion, high dependency ratio and mounting social problems, emigration, higher unemployment and/or underemployment, inequality including the current acts of insurgency and terrorism. Thus, appropriate measures should be taken to curb this growing menace which may become endemic in the Nigerian economy resulting in pervasive poverty and portends danger to sustainable development. Another scholar noted that the role of agriculture in the process of economic development has both economic and political roots<sup>53</sup>. It was argued that if the role is passive requiring only gradual transfers of capital and labour to the industrial sector, the government's role in the agricultural sector can be minimal or even discriminatory, through heavy taxation. If agriculture plays a more positive role in stimulating growth in other sectors, but needs to grow rapidly itself for the stimulation to be effective, the government's role may need to be more active. As a third possibility, he suggests that governments might need to intervene much more actively in agricultural development if non-market growth linkages are stimulated by rapid growth of agricultural incomes.

Another study titled "Agricultural Land Use and Population Growth in Nigeria focused on the Need for Synergy for a Sustainable Agricultural Production" revealed annual exponential growth rates of 0.62% for the agricultural land and 0.72% for arable land in the time frame considered. Likewise, the exponential growth rates of

2.57%, 1.67% and 4.75% were obtained for the total population, rural and urban population, respectively<sup>48</sup>. Additionally, significant positive correlations between population and agricultural land variables were established in Nigeria. The findings further revealed that the annual increment in the total output of some arable crops like cassava, yam, cocoa bean, maize, sorghum, groundnut and rice were mostly due to land expansion than an increase in land productivity. Based on these results, the apparent reason to implement several population policies enacted previously in the country is justifiable. It is also shown that agricultural land-related variables and population variables have significant exponential growth rates in the period considered. This is an indication that farmland is not used sustainably amidst the mounting population pressure. In conclusion, the country needs to efficiently harness its enormous human and natural resources to ensure short- and long-term sustainable development in agriculture.

In a study, population growth and food security in Nigeria, using simple regression analysis technique, concludes that population growth affects negative agricultural output in Nigeria<sup>61</sup>. Thus, given rise the food insecurity. Peters examines the relationship among population dynamics, savings and agricultural output in Nigeria<sup>99</sup>. It was found that population dynamics affects savings negatively, and this affects investment in the agricultural sector, leading to low agricultural output. It is this poor yield in agricultural produced, emanating from the dynamic nature of the population that resulted into food insecurity that characterized the Nigerian economy. This partly explained the rise in food import bill in the country. Another scholar investigates oil resource management and good insecurity in Nigeria. He uses the unrestricted Vector Autoregressive (VAR) model and found that over dependence oil resulted in the neglect of the agricultural sector, hence the decline in food production for the teeming

population in Nigeria<sup>55</sup>. This is an archetype of Dutch disease, because before the advent of oil exploitation and exploration agriculture was the mainstay of the Nigerian economy. Another scholar examines strategies for food security and health improvement in the sub-Saharan Africa<sup>98</sup>. They established that sub-Saharan Africa is plagued by poverty and severe malnutrition, with 30 to 45 countries plunged into food crisis. Another scholar investigates food security in Sudan<sup>91</sup>. He states that Sudan's poor domestic policy affected farmers negatively, giving rise to persistent hunger and malnutrition. He pointed out that the civil unrest put peasant farmers and the entire population at a great disadvantage. Another scholar in his study food security and sustainable development in India, states that, the capacity to achieve a balance between the population of the people and the production of food grains and other agricultural products was marked by a sense of despair<sup>100</sup>. Another scholar investigates food security in sub-Saharan Africa<sup>101</sup>. He found that about 840 million people globally are malnourished and the most affected in the African continent. He contends that efforts to address food security have proven abortive and food insecurity becomes the order of the day. Other scholars examine the socio-economic characteristics and food security status of farming households in Kwara State, North central<sup>64</sup>. They used three-stage random sampling technique to obtain a sample of 94 respondents. The result shows that 36 percent of the respondent households were food secure, while 64 percent of respondent households are food insecure. This result gives credence to the prevalence of food insecurity in the country.

Another scholar examined population growth and food security in Nigeria using the cointegration approach<sup>71</sup>. Their findings indicate that population has an adverse effect on food security. They assert that food security is necessary for the following reasons: First, many countries, especially the developing countries have had tortuous uprisings,

resulting to instability and overthrowing of governments. Such revolt according to other scholar had their root causes insufficient supply of the major staple food stuffs and the attendant high prices. If such instabilities are to be checkmate then adequate attention must be devoted to ensuring food, self-sufficiency and security because a hungry man is an angry man.

#### **2.4 Gaps in Literature Review**

Several studies by different scholars such as According to Chavis financial incentives in form of tax deductions and social welfare, which is put in place to assists parents to cater for their children assisted in producing more children<sup>103</sup>. Other factor is fertility treatment drugs, which allows multiple fertilized eggs to be injected and Peters examines the relationship among population dynamics, savings and agricultural output in Nigeria<sup>99</sup>. He found that population dynamics affects savings negatively, and this affects investment in the agricultural sector, leading to low agricultural output. It is this poor yield in agricultural produced, emanating from the dynamic nature of the population that resulted into food insecurity that characterized the Nigerian economy. This partly explained the rise in food import bill in the country but fail to consider the asymmetric causal relationship between population growth and food production which is one of the objectives of this study

Also considering other investigation on food security in sub-Saharan Africa<sup>101</sup>. He found that about 840 billion people globally are malnourished and the most affect in the African continent. He contends that efforts to address food security have proven abortive and food insecurity becomes the order of the day. He fails to consider the effect of the growing population on the food production which this study is also going to focus.

While studying population growth and food security in Nigeria between the period of 2000 to 2012, did a comparative analysis of the population growth rates of Nigeria, India, and United State of America ,it was observed that within this period, Nigeria witnessed high growth rate when compared to India and United State of America<sup>61</sup> .On average within the study period the country witnessed 0.99% growth rate in its population. It therefore becomes pertinent to investigate the reasons for population growth rates. Some of the factors leading to this according to Abdul Rahman include crude birth rate of about 44 per 1000, relative high fertility level with a rate of 6.0 live-births per woman in the 1990s. Another scholars Tasim research on the causes of rapid population growth in India: includes high fertility rate, in 2000 the birth rate was 25.8 per 1000 principally caused by early marriage, universal marriage and joint family system<sup>104</sup>. Mortality rate was very low as at 1991 the death rate was 10 per 1000, this reduced to 8.5 per 1000 in 2000 due effective control of epidemic and other deadly diseases, development of medical centers and the decline of infant mortality rate. The number of Indian immigrants also contributes to the population explosion having the least population growth rate, the factors were considered in the studies but the response of food production to shocks in population growth was not considered by the scholars and this form a basis for more research work.

#### **2.4 Theoretical Framework**

The framework of this study is founded on the Malthusian theory of population. The theory stated that the growth of population is higher than that of the growth of food production. This was explained further that while population grows at a geometrical rate, food production grows at an arithmetical or subsistence level. The theory is therefore based on the inability of the growth of food production to satisfy the needs

of a growing population. However, the growth of food production is determined by the population of the economy. This relationship can therefore be expressed as:

$$FP = f(\text{POPG}) \quad (2.1)$$

Where,

FP = food production

POP = Population growth

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## Chapter Three

### Methodology

#### 3.0 Preamble

This chapter discuss the methods that is used in achieving the objectives of this study. The type and scope of the data used as well as the source of the data used for estimation was presented. The model of the study was also specified and the technique of estimation as well as the apriori expectation.

#### 3.1 Model Specification

The general model for this study is based on the Malthus theory in the previous chapter with the aim of investigating the nexus between food production and population growth. The model is formulated from the equation 2.1 which can be expressed statistically as:

$$FP_t = \alpha_0 + \alpha_1 POPG_t + \varepsilon_t \quad (3.1)$$

From the equation 3.1, food production (FP) is measured by agricultural GDP (AGDP), while POPG is the growth of population. In addition, there are other macroeconomic variables identified by scholars which determine food production such as commercial bank loan to agriculture, government expenditure on agriculture, labour, inflation and exchange rate<sup>1,2</sup>. Integrating these into the model, it can be re-expressed statistically as:

$$AGDP_t = \alpha_0 + \alpha_1 POPG_t + \alpha_2 DCA_t + \alpha_3 GEA + \alpha_4 LFP_t + \alpha_5 EXR_t + \alpha_6 INF_t + \varepsilon_t \quad (3.2)$$

Where,

AGDP is agricultural output as a percentage of GDP

POPG is the growth of population

DCA is the deposit money bank credit to agriculture

LFP is the labour force participation rate

EXR is the exchange rate

INF is the inflation rate

$\alpha_0$  is the intercept

$\alpha_{1-6}$  are the coefficient of the independent variables

$\varepsilon$  is the error term

### **3.1.1 Model of the Asymmetric Causal Relationship Between Population Growth and Food Production in Nigeria.**

To estimate the asymmetric causal relationship between population growth (POPG) and food production in Nigeria (AGDP), the data will be filtered through the VAR model to obtain the residual series, and then the residual series will be used for the nonlinear Granger causality analysis. In this study, the nonlinear Granger causality test proposed by Diks and Panchenko is used<sup>3</sup>.

In determining the asymmetric causality, if the past and present values of  $POPG_t$  contain the additional information about the future value of  $GDP_t$ , then  $POPG_t$  can strictly Granger cause  $AGDP_t$ . Let  $F_{X,t}$  and  $F_{Y,t}$  denote the set of past observations that contain  $POPG_t$  and  $AGDP_t$  before time  $t + 1$ , respectively. Let  $\sim$  represent the equivalence of the distribution. The time series  $POPG_t$  can strictly Granger cause  $AGDP_t$  when the following conditions are met:

$$(AGDP_{t+1}, \dots, AGDP_{t+k}) | (F_{X,t}, F_{Y,t}) \sim (AGDP_{t+1}, \dots, AGDP_{t+k}) | F_{X,t} \quad (3.3)$$

where  $k \geq 1$  represents the boundary of the predict, and at the time  $k = 1$ , the conditional distribution of  $Y_t$  is compared with and without the past and present values of  $X_t$ . Suppose the lag vector matrices

$$\text{POPG}_t^{L_x} = (\text{POPG}_{t-L_x+1}, \dots, \text{POPG}_t) \text{ and } \text{AGDP}_t^{L_y} = (\text{AGDP}_{t-L_y+1}, \dots, \text{AGDP}_t) \dots \quad (3.4)$$

The null hypothesis assumes

That  $X_t^{L_x}$  does not contain any information that can predict the value of  $\text{AGDP}_t^{L_y}$  as follows:

$$H_0 : \text{AGDP}(t+1) | (\text{AGDP}_t^{L_y}; \text{AGDP}_t^{L_y}) \sim Y(t+1) | \text{AGDP}_t^{L_y} \quad (3.5)$$

For a strictly stationary bivariate time series, Equation (3.5) means that the distribution of the  $(L_x + L_y + 1)$  dimensional vector  $W_t = (\text{POPG}_t^{L_x}, \text{AGDP}_t^{L_y}, Z_t)$  will remain constant, where  $Z_t = \text{AGDP}_{t+1}$ . To keep the presentation compact and easy to discuss, the time subscript is removed, and  $L_x = L_y = 1$  is assumed. Then, under these assumptions, the conditional distribution of  $Z$ , given  $(\text{POPG}, \text{AGDP}) = (x, y)$ , is the same as that of  $Z$  given  $\text{AGDP} = y$ . Thus, Equation (3.5) can be re-expressed by the joint probability density function, as follows:

$$\frac{f_{x,y,z}(x,y,z)}{f_Y(y)} = \frac{f_{x,y}(x,y)}{f_Y(y)} \cdot \frac{f_{Y,z}(y,z)}{f_Y(y)} \quad (3.6)$$

According to Equation (3.7),  $\text{POPG}$  and  $Z$  are conditional and independent of  $\text{AGDP} = y$  for each fixed  $y$  value, so the modified null hypothesis  $H_0$  indicates that the following relation is established:

$$Q \equiv E[f_{x,y,z}(x,y,z)f_Y(y) - f_{x,y}(x,y)f_{Y,z}(y,z)] = 0 \quad (3.7)$$

Let  $\hat{f}_w(W_i)$  denotes the local density function estimated value of the random vector  $W$  at  $W_i$ , as follows:

$$\hat{f}_w(W_i) = \frac{(2\varepsilon_n)^{-dw}}{(n-1)} \sum_{j,j \neq i} I_{ij}^W \quad (3.8)$$

where  $I_{ij}^W = I(\|W_i - W_j\| < \varepsilon_n)$ ,  $I(\cdot)$  is the index function, and  $\varepsilon_n$  is the bandwidth parameter associated with the number of samples ( $n$ ). When a local density function is given an estimation, the following test statistic is constructed:

$$T_n(\varepsilon_n) = \frac{n-1}{n(n+2)} \cdot \sum_i (\hat{f}_{x,y,z}(POPG_i, AGDP_i, Z_i) \hat{f}_{\gamma}(AGDP_i) - \hat{f}_{x,y}(POPG_i, AGDP_i) \hat{f}_{\gamma,z}(POPG_i, Z_i)) \quad (3.9)$$

For  $L_x = L_y = 1$ , when  $\varepsilon_n = Cn^{-\beta}$  ( $C > 0, \frac{1}{4} < \beta < \frac{1}{3}$ ), the statistic  $T_n(\varepsilon_n)$  satisfies the following condition:

$$\sqrt{n} \frac{(T_n(\varepsilon_n) - q)}{S_n} \xrightarrow{D} N(0,1) \quad (3.10)$$

where  $\xrightarrow{D}$  denotes the distribution convergence, and  $S_n$  denotes the estimated value of the asymptotic variance of  $T_n(\cdot)$ .

### 3.1.2 Model of the Asymmetric Effect of Population Growth on Food Production in Nigeria.

To estimate the asymmetric effect of population growth on food production in Nigeria, this study adapts the asymmetric ARDL of Shin, Yu and Greenwood which was derived from the expansion of the linear ARDL<sup>4</sup>. In line with the study by these scholars, the non-linear long run equation is specified as

$$agdp_t = \alpha_0 + \alpha_1 popg_t^+ + \alpha_2 popg_t^- + \alpha_3 dca_t + \alpha_4 ge_t + \alpha_5 lfp_t + \alpha_6 exr_t + \alpha_7 inf_t + \mu_t \quad (3.11)$$

Where  $popg_t$  is a  $k \times 1$  vector of regressors.

Given that  $\text{int}_t$  is defined to be a random walk, such that:

$$\text{popg}_t = \text{popg}_{t-1} + \mu_t, \quad \mu_t \sim N(0, \sigma_e^2) \quad (3.12)$$

The above data generating process may be re-written as follows after recursive substitution;

$$\text{popg}_t = \text{popg}_0 + \sum_{j=1}^t \mu_j, \quad t=1, \dots, \quad (3.13)$$

Assuming zero threshold, the error term can be partitioned as;

$$\mu_t = \mu_t^+ + \mu_t^- \quad (3.14)$$

Taking partial sum yield;

$$\sum_{j=1}^t \mu_j = \sum_{j=1}^t \mu_j^+ - \sum_{j=1}^t \mu_j^- \quad (3.15)$$

From the foregoing, the following expression follows:

$$\mu_j^+ = \Delta \text{popg}_j^+ \text{ and } \mu_j^- = \Delta \mu_j^- \quad (3.16)$$

$\mu_t^+$  and  $\mu_t^-$  are partial sums of the positive and negative changes in popg.

Thus,  $\mu_t$  which is a  $k \times 1$  vector of regressors is defined as;

$$\text{popg}_t = \text{popg}_t + \text{popg}_t^+ + \text{popg}_t^- \quad (3.17)$$

Linking equation 3.2 to the symmetric ARDL of Shin, Yu, and Greenwood, the following non-linear variant of the unrestricted ECM is obtained;

$$\begin{aligned} \Delta \text{agdp}_t = & \alpha_0 + \rho \text{agdp}_{t-1} + \alpha_1 \text{popg}_{t-1}^+ + \alpha_2 \text{popg}_{t-1}^- + \sum_{j=1}^{\rho-1} \theta_j \Delta \text{agdp}_{t-1} + \\ & \sum_{j=0}^{q-1} \pi_j^+ \Delta \text{popg}_{t-j}^+ + \sum_{j=0}^{q-1} \pi_j^- \Delta \text{popg}_{t-j}^- + \mu_t \end{aligned} \quad (3.18)$$

Where  $\alpha_1 = -\rho\beta^+$  and  $\alpha_2 = -\rho\beta^-$  and  $\theta_j$  is the autoregressive parameter;  $\pi_j^+$  and  $\pi_j^-$  are the symmetric distributed lag parameters;  $\mu_t$  is the stochastic error term that is independently and identically distributed with zero mean and constant variance.

Equation (3.8) may be re-written as;

$$\Delta agdp_t = \alpha_0 + \rho agdp_{t-1} + \alpha_1 popg_{t-1}^+ + \alpha_2 popg_{t-1}^- + \sum_{j=1}^{p-1} \theta_j \Delta agdp_{t-1} + \sum_{j=0}^{q-1} (\pi_j^+ \Delta popg_{t-j}^+ + \pi_j^- \Delta popg_{t-j}^-) + \mu_t \quad (3.19)$$

The restricted ECM may be written as;

$$\Delta agdp_t = \kappa_1 ecm_{t-1} + \sum_{j=1}^{p-1} \theta_j \Delta agdp_{t-1} + \sum_{j=0}^{q-1} (\pi_j^+ \Delta popg_{t-j}^+ + \pi_j^- \Delta popg_{t-j}^-) + \mu_t \quad (3.20)$$

### 3.1.3 Model for the accessing the response of food production to shocks in population growth in Nigeria.

To achieve the third objective, the study adapts the unrestricted vector autoregressive (VAR) approach developed by Sims in estimating Seven-variable VAR models using  $agdp_t, popg_t, dca_t, ge_t, lfpb, inf_t, exr_t$  to provide an empirical insight on the response of food production to shocks in population growth in Nigeria<sup>5</sup>. The model is stated as:

$$X_t = u + A_1 X_{t-1} + \dots + A_p X_{t-p} + u_t \quad (3.21)$$

Where  $X_t$  is a 7x1 vector matrix incorporating  $agdp_t, popg_t, dca_t, ge_t, lfp, inf_t, exr_t$  as variables;  $A$  is a matrix polynomial for the lag operator of considered variables; and  $U_t$  is a vector of un-estimated shocks for each of the population growth and other controlling variables and it is assumed to be serially uncorrelated structural disturbance for  $Var(u_t) = \Omega$ . where  $\Omega$  is a diagonal matrix, so the structural disturbances are assumed to be mutually uncorrelated.

### 3.2 Data Measurement and Description of Variable

This study measures food production using agricultural contribution to GDP and population growth rate which is the change in the number of individuals in a geographical area (Nigeria) over a specific period of time. Other variables included in

this study include credit facilities available to agriculture measured by commercial bank loan to agriculture and government expenditure to agriculture as well as macroeconomic variables such as exchange rate, inflation, and labour force.

### 3.3 Data Requirement and Sources

For this study, time series (annual) data were obtained from the CBN Statistical Bulletin and the World Bank World Development Indicators. The variables used and their measurement are defined in the table below.

**Table 3.1: Description Measurement of the Variables in the Study**

Variable	Indicator	Description
Food Production (AGDP)	Agriculture, forestry, and fishing, value added (% of GDP)	This is an economic indicator that measures the contribution of these sectors to the overall economic output of a country. It represents the value of goods and services produced by the agriculture, forestry, and fishing industries, after deducting the cost of inputs such as seeds, fertilizers, and other materials.
Population Growth (POPG)	Population growth (annual %)	This indicator that measures the rate at which a population is increasing or decreasing over a period of one year. It is expressed as a percentage, and is calculated as the difference between the number of births and deaths in a population, plus the net migration rate (the number of immigrants minus the number of emigrants), divided by the total population, multiplied by 100.
Labour Force Participation (LFP)	Labor force participation rate, total (% of total population ages 15+) (modeled ILO estimate)	This is a measure of the percentage of the working-age population (those aged 15 years and older) who are either employed or actively seeking employment. This indicator is based on a modeled estimate by the International Labour Organization (ILO).
Inflation (INF)	Inflation, Consumer Prices (Annual %)	Inflation measured by consumer price index (CPI) is described as the change in the prices of a basket of goods and services that are typically purchased by specific groups of households.
Government Expenditure(GE)	Government Expenditure (% of GDP)	This is an economic indicator that measures the total amount of money a government spends on goods and services, expressed as a percentage of the country's Gross Domestic Product (GDP).
Exchange Rate (EXR)	Official Exchange Rate (LCU Per US\$, Period Average)	Exchange rate is the price of one currency in terms of another currency.
Bank Credit to Agriculture (DCA)	Deposit Money Bank Credit to Agriculture (% of GDP)	This is an economic indicator that measures the extent to which deposit money banks (DMBs) are providing credit to the agricultural sector of an economy. It represents the total value of loans disbursed by DMBs to the agricultural sector, as a percentage of the country's Gross Domestic Product (GDP).

### 3.4 Estimation Procedure

In order to achieve the objectives of this study using the specified model, the variables will be subjected to the test of stationarity using the Augmented Dickey-Fuller test which uses non-parametric statistical methods to take care of the serial correlation in the error terms without adding lagged difference terms.

The first objective of this study which is to estimate the asymmetry causality relationship between population growth and food production in Nigeria will be accessed using the asymmetry causality based on Toda Yamamoto test. This utilizes a modified Wald test for restrictions on the parameters of a VAR (k) model (where k is the lag length in the system). Toda and Yamamoto proved that this test has an asymptotic  $\chi^2$  distribution when a VAR (k+ d max) model is estimated (where d max is the maximal order of integration suspected to occur in the system). The advantage of this procedure is that it does not require knowledge of cointegration properties of the system. This test can be done even if there is no cointegration and/or the stability and rank conditions are not satisfied.

To estimate the asymmetry effect of population growth on food production in Nigeria, the asymmetry ARDL bound test will be conducted to test for cointegration of the variables. After establishing a long run relationship, the Non-linear Autoregressive Distributed Lag (NARDL) will then be estimated to establish a long run and short run non linear asymmetric relationship.

To determine the response of food production to sudden changes in population growth in Nigeria. This will be achieved using the impulse response function and variance decomposition tests. The Impulse Response Function (IRF) will be used to graphically examine how food production reacts to population growth changes. The

IRF inspects how the dependent variable in the VAR model reacts to shocks in the error terms. What is desirable about the IRF, is that it allows for the response analysis of each shock to each variable in the model, holding other shocks and variables constant. Variance decomposition assists with the interpretation of an estimated VAR model by explicitly specifying the proportion at which each variable's forecast errors can be explained by its own shocks against exogenous shocks to other variables in a regression model. Given the statistical efficacy of variance decomposition, this study will make use of variance decomposition to examine how population growth changes impacts food production in Nigeria.

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## Endnotes

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- <sup>2</sup>J. Reuben, C. M. Nyam, and D. T. Rukwe, "Agricultural Credit Guarantee Scheme Fund and Its Effect on Agricultural Output in Nigeria," **Review of Agricultural and Applied Economics (RAAE)** 23, no. 1340-2021-020 (2020): 102-111
- <sup>3</sup>J. Runge, A. Gerhardus, G. Varando, V. Eyring, and G. Camps-Valls, "Causal Inference for Time Series," **Nature Reviews Earth & Environment** 4, no. 7 (2023): 487-505.
- <sup>4</sup>A. Mujtaba, P. K. Jena, F. V. Bekun, and P. K. Sahu, "Symmetric and Asymmetric Impact of Economic Growth, Capital Formation, Renewable and Non-Renewable Energy Consumption on Environment in OECD Countries," **Renewable and Sustainable Energy Reviews** 160 (2022): 112300.
- <sup>5</sup>Sims, C. A. (1980b), Comparison of Interwar and Postwar Business Cycles: **Monetarism Reconsidered**, *American Economic Review* 70 (2), 250–257

## Chapter Four

### Results and Discussion of Findings

#### 4.0 Preamble

This chapter presents the analysis, results and interpretations of the findings of this study. The discussion commence with the preliminary study consisting of descriptive statistics, trend analysis and correlation analysis followed by the pre-estimation tests, where the unit root and co-integration tests were carried out. The chapter also provided some diagnostic tests using some test statistics in order to ensure that the estimated results are reliable for meaningful inferences. This chapter concludes with a discussion of findings from the analysis.

#### 4.1 Preliminary Analysis

The preliminary analysis presented in this study include the trends analysis, descriptive statistics and correlation analysis of the variables for empirical analysis for empirical analysis based on the formulated hypothesis. Facts of the trends of agricultural output as a percentage of GDP (AGDP), growth of population (POPG), deposit money bank credit to agriculture (DCA), labour force participation rate (LFP), exchange rate (EXR), Government Expenditure as a Percentage of GDP (GE), and inflation rate (INF) are presented using trends and summary statistics.

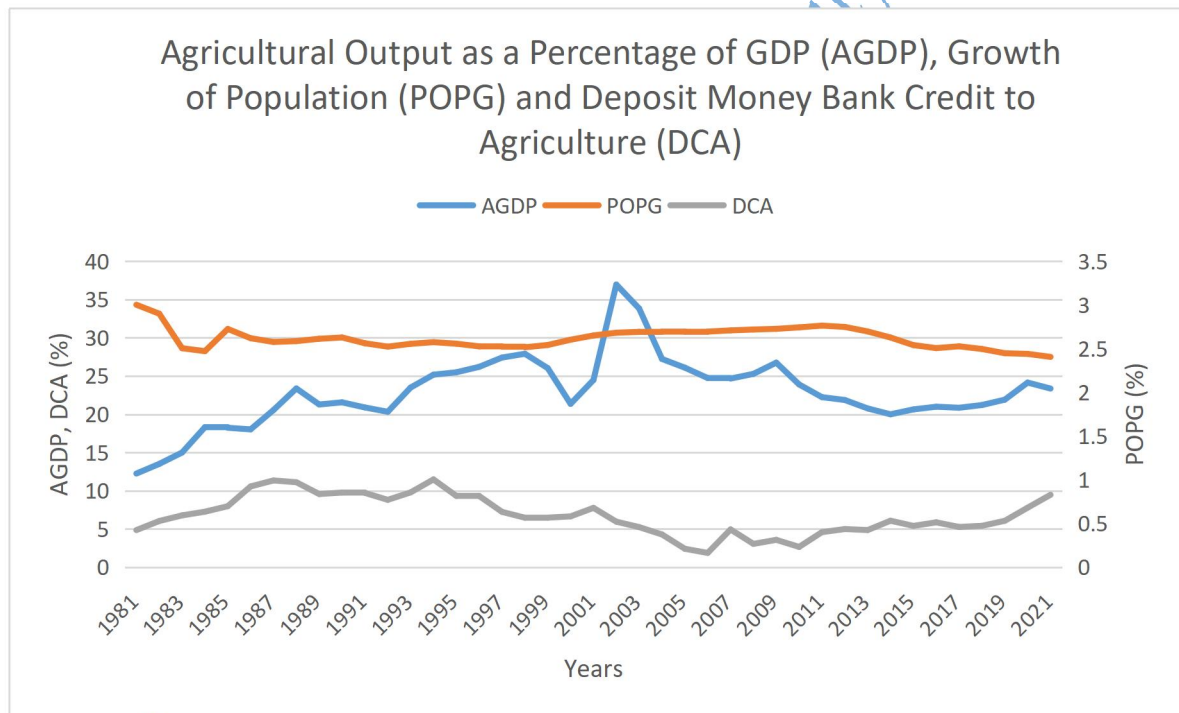
##### 4.1.1 Presentation of Data

The data used in the analysis of this study is presented in the appendix 1. The table shows the time series annual data from 1981 to 2020 for the variables agricultural output as a percentage of GDP (AGDP), growth of population (POPG), deposit money bank credit to agriculture (DCA), labour force participation rate (LFP),

exchange rate (EXR), inflation rate (INF) and Government Expenditure as a Percentage of GDP (GE).

#### 4.1.2 Graphical Trend Analysis of Variables

The trend of each variable and the relationship among the variables are discussed below using graphical analysis. The trends are presented such that the relationship between AGDP and POPG are discussed in relation with other variables (DCA, LFP, GE) over the period under investigation.



**Figure 4.1: Trend Analysis of Agricultural Output as a Percentage of GDP (AGDP), Growth of Population (POPG) and Deposit Money Bank Credit to Agriculture (DCA)**

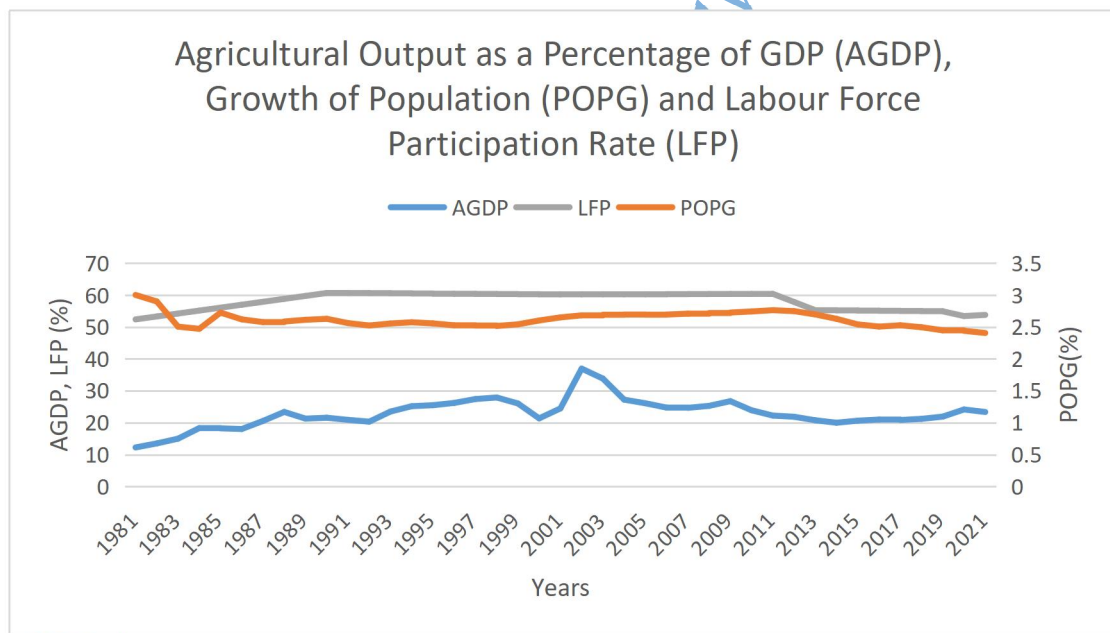
**Source:** Authors Computation 2023

The figure 4.1 shows the trend behaviour of Agricultural Output as a Percentage of GDP (AGDP), Growth of Population (POPG) and Deposit Money Bank Credit to Agriculture (DCA) from 1981 to 2021. It was observed from the AGDP graph that it shows a gradual increase from 1981 to 1984, followed by relatively stable levels until around 1997. From 1997 to 2000, there is a sharp decline in AGDP, which could be attributed to various factors such as drought, economic instability, or policy changes affecting the agricultural sector. After 2000, AGDP shows some fluctuations but overall demonstrates an upward trend, starting with a sharp rise between 2002 and 2003 followed by occasional periods of slight decline. This could be as a result of government policy and investments aimed at boosting agriculture outputs. The sudden downward movement in AGDP in the mid-1990s and subsequent recovery may indicate the impact of external shocks or internal factors affecting agricultural productivity in Nigeria.

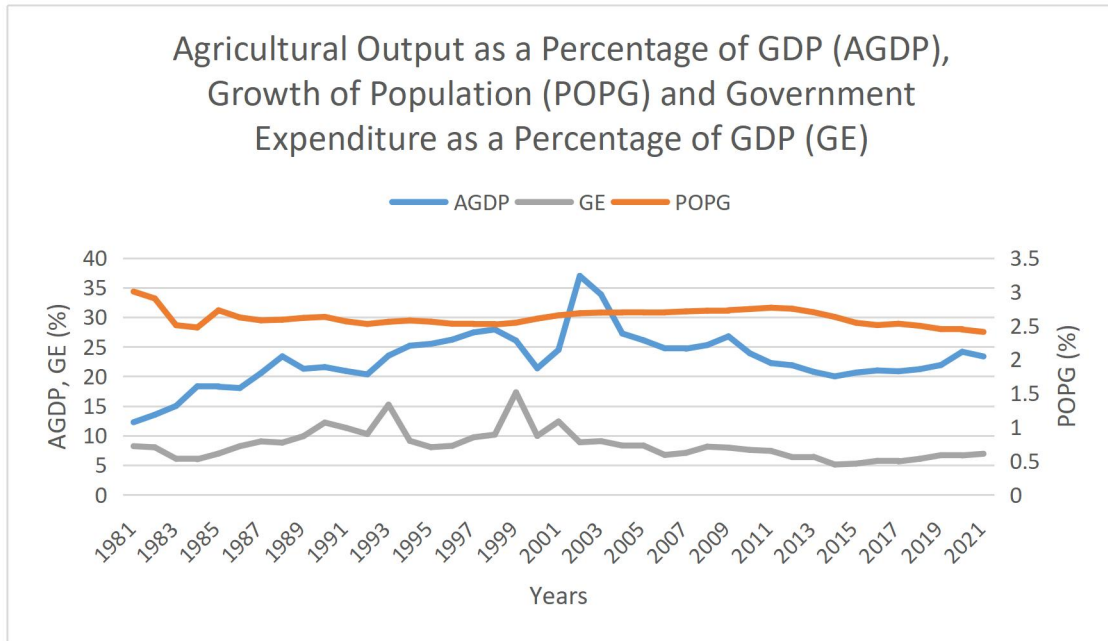
At the same time, POPG shows a consistent increase in population growth from 1981 to around 2005 notwithstanding the fluctuations in AGDP. This upward trend is expected given the natural growth of the population over time. However, after 2005, there is a noticeable deceleration in population growth, with a relatively slower increase until 2021. The sudden downward movement in population growth around 2005 could be due to changes in demographic patterns, improved family planning measures, or other social and economic factors influencing birth rates. Understanding

the reasons behind these shifts in population growth is essential for assessing their impact on food production.

DCA on the other hand which indicate the amount of deposit money bank credit allocated to agriculture over the years shows that from 1981 to 1995, there is a general increasing trend, which is also followed by an increase in AGDP during the same period, suggesting a growing focus on supporting agricultural activities through credit facilities. However, after 1995, there is a sudden drop in DCA, followed by periods of fluctuation. The downward movement in DCA could be attributed to changes in banking policies, economic conditions, or shifts in priorities within the financial sector.



**Figure 4.2: Trend Analysis of Agricultural Output as a Percentage of GDP (AGDP), Growth of Population (POPG) and Labour Force Participation (LFP)**  
**Source:** Authors Computation 2023



**Figure 4.3: Trend Analysis of Agricultural Output as a Percentage of GDP (AGDP), Growth of Population (POPG) and Government Expenditure as a Percentage of GDP (GE)**  
**Source:** Authors Computation 2023

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In line with the foregoing, the government expenditure (GE) demonstrates a relatively stable upward movement from 1981 to 1993, with gradual increases in government expenditure as a percentage of GDP. However, in 1994, there is a sudden downward movement where GE experiences a significant decrease. From 1994 to 1999, GE shows a declining trend. After 1999, there is a sudden upward movement in GE, with a substantial increase until around 2003. From 2003 to 2010, GE displays a relatively stable upward trend, followed by a slight decline until around 2016. After 2016, GE exhibits a gradual increase. These sudden changes can be attributed to government policies from different administrations which requires different level of government expenditure in different sectors.

Meanwhile the trend behaviour of labour force participation rate (LFP) which represents the proportion of the working-age population that is actively engaged in the labor force shows a relatively stable pattern with minor fluctuations over time. From 1981 to around 2012, the LFP remains around the same level, indicating a consistent labor force participation rate. However, from 2012, there is a sudden fall in LFP and continue to maintain a relatively stable growth till 2021. This could be due to various factors such as changes in employment patterns, shifts in the economy towards non-agricultural sectors, or policy changes impacting labor force participation.

#### **4.1.3 Descriptive Statistics of Variables**

The descriptive statistics showing the properties of the variables used in this study is presented in table 4.1 below. The table shows the summary of statistics of agricultural output as a percentage of GDP (AGDP), growth of population (POPG), deposit money bank credit to agriculture (DCA), labour force participation rate (LFP), exchange rate (EXR), Government Expenditure as a Percentage of GDP (GE), and inflation rate (INF) between 1981 and 2021.

These descriptive statistics provide an overview of the central tendency, variability, skewness, kurtosis, and normality of the variables in the study. It helps in understanding the average values, distribution shapes, and ranges of the variables, which can further inform the analysis and interpretation of their relationships in the context of the nexus between population growth and food production in Nigeria.

**Table 4.1: Descriptive Statistics**

	<b>AGDP</b>	<b>POPG</b>	<b>LFP</b>	<b>DCA</b>	<b>GE</b>	<b>INF</b>	<b>EXR</b>
Mean	22.8694	2.6232	58.2589	0.5867	8.4452	18.9989	100.7601
Median	22.0705	2.6082	60.2635	0.5484	8.1500	12.7157	106.4643
Maximum	36.9650	3.0029	60.6730	1.0039	17.2861	72.8355	358.81
Minimum	12.2404	2.4406	52.4000	0.1626	5.0893	5.3880	0.6177
Std. Dev.	4.6476	0.1190	2.7167	0.2225	2.5522	16.8684	100.7283
Skewness	0.4428	0.9423	-0.7028	0.1667	1.4950	1.8234	0.8887
Kurtosis	4.6244	4.1895	1.8691	2.2435	5.7402	5.1590	2.9947
Jarque-Bera	5.7053	8.2781	5.4245	1.1390	27.4153	29.9363	5.2654
Probability	0.0576	0.0159	0.0663	0.5657	0.0000	0.0000	0.0718
Sum	914.77	104.93	2330.35	23.47	337.81	759.95	4030.41
Sum Sq.							
Dev.	842.4082	0.5524	287.8455	1.9315	254.04	11097.27	395701.7
Observations	40	40	40	40	40	40	40

**Source:** Author's computation

From the result in table 4.1, it can be observed that AGDP has a mean of approximately 22.87%. This indicates that agriculture contributes about 22.87% to the overall GDP of Nigeria on average within the period under consideration. Also, between 1981 and 2021, the maximum and minimum values of AGDP are 36.97% and 12.24%, respectively. This shows that agricultural output has varied between these extremes during the observed period. The standard deviation of AGDP is 4.65%, indicating a moderate amount of variability or dispersion around the mean value. The skewness value of 0.44 indicates a slight right-skewness, implying a relatively longer right tail, while the positive kurtosis value of 4.62 indicates the presence of outliers or extreme values in the distribution. The Jarque-Bera test which assesses the normality of the distribution has a p-value of 5.71% suggests that the distribution of AGDP is

not significantly different from a normal distribution at a conventional significance level of 5%.

With regards to POPG (Population Growth), the average population growth rate in Nigeria within is approximately 2.62%. This indicates that the population has been growing at an average annual rate of 2.62% during the observed period. The maximum and minimum values of POPG are 3.00% and 2.44%, respectively with a standard deviation of POPG is 0.12%, suggesting a relatively low variability in population growth rates. The positive skewness value of 0.94 indicates a right-skewed distribution, meaning there might be a few periods with higher population growth rates. The kurtosis value of 4.19 suggests the presence of some outliers or extreme values. The p-value of 0.02% from the Jarque-Bera test indicates that the distribution of POPG is not normally distributed.

The labour force participation rate (LFP) in Nigeria has an average value of 58.26%. This indicates that approximately 58.26% of the working-age population actively participates in the labor force. The distribution of participation rates is slightly left-skewed, with a range of 52.40% to 60.67%. The data shows moderate variability (standard deviation = 2.72%) around the mean. While the distribution is slightly negatively skewed and distributed normally based on the Jarque-Bera test. Deposit money bank credit to the agriculture sector (DCA) in Nigeria has an average value of 0.59%. This indicates that, on average, 0.59% of the credit provided by deposit money banks is directed towards agriculture. The distribution of credit to agriculture is slightly left-skewed, with a range of 0.16% to 1.00%. The variability in credit allocation is moderate, with a standard deviation of 0.22. The Jarque-Bera test suggests that the distribution is normally distributed.

With respect to GE, INF and EXR, it was found that government expenditure (GE) in Nigeria contributes, on average, 8.45% to the country's GDP. The distribution of government expenditure as a percentage of GDP is slightly left-skewed, with a range of 5.09% to 17.29%. There is a moderate amount of variability (standard deviation = 2.55%) in government expenditure. The distribution exhibits positive skewness and positive kurtosis, indicating a right-skewed distribution with a relatively higher concentration of values on the right side of the mean. The Jarque-Bera test suggests that GE is not normally distributed. While the average inflation rate (INF) in Nigeria during the observed period is approximately 19.00%. This indicates that prices have been increasing at an average annual rate of 19.00%. The distribution of inflation rates is right-skewed, with a range of 5.39% to 72.84%. There is a significant amount of variability (standard deviation = 16.87%) in the inflation rate data. The distribution exhibits positive skewness and positive kurtosis, indicating a right-skewed distribution with a relatively higher concentration of values on the right side of the mean. The Jarque-Bera test indicates that the distribution is not normally distributed.

The average exchange rate (EXR) in Nigeria is approximately 100.76 Nigerian Naira per unit of another currency (e.g., USD). The distribution of exchange rates is slightly right-skewed, with a range of 0.62 to 358.81. There is a significant amount of variability (standard deviation = 100.73%) in the exchange rate data. The distribution exhibits a slightly right-skewed shape, indicating a relatively lower concentration of values on the left side of the mean. The kurtosis value suggests the presence of some outliers or extreme values. The Jarque-Bera test indicates that the distribution is normal.

## 4.2 Pre-Estimation Test

In order to determine the appropriateness of the method to be used for empirical analysis in this study, some pre-estimation test were carried out to determine the thecorrelation , stationarity level and the cointegration of the variables.

### 4.2.1 Correlation Analysis

The table 4.2 below presents the correlation analysis result among the variables of this study. It show the degree of association between agricultural output and population growth as well as other macroeconomic variables between 1981 and 2021.

**Table 4.2 Correlation Matrix**

	AGDP	POPG	LFP	DCA	GE	INF	EXR
AGDP	1						
POPG	-0.1520	1					
LFP	0.6627	-0.0067	1				
DCA	-0.1463	-0.4248	0.0831	1			
GE	0.2521	-0.0559	0.5695	0.3731	1		
INF	0.0500	-0.2082	0.2449	0.5195	0.2216	1	
EXR	0.1792	-0.2093	-0.3190	-0.5112	-0.4276	-0.3418	1

**Source:** Author's computation

The results as shown in the table 4.2 indicates that the Agricultural Output as a Percentage of GDP (AGDP) has a correlation coefficient of -0.1520 with POPG, indicating a weak negative correlation between agricultural output and population growth. This suggests that as the population grows, there is a slight tendency for agricultural output as a percentage of GDP to decrease. AGDP has a strong positive correlation of 0.6627 with Labour Force Participation Rate (LFP). This imply that a higher participation rate in the labor force is associated with a greater agricultural output as a percentage of GDP. This makes intuitive sense, as increased labor force participation can contribute to higher agricultural productivity. On the other hand, AGDP has a weak negative correlation of -0.1463 with DCA (Deposit Money Bank Credit to Agriculture), indicating that as bank credit to the agricultural sector

increases, there is a slight tendency for agricultural output as a percentage of GDP to decrease.

There is also found a moderate positive correlation of 0.2521 between AGDP and GE (Government Expenditure as a Percentage of GDP). The implication of this is that higher government expenditure as a percentage of GDP is associated with a greater agricultural output. Increased government investment in agriculture can enhance productivity and stimulate growth in the sector. There is a weak positive correlation of 0.0500 between AGDP and INF (Inflation Rate) which indicate that as the inflation rate increases, there is a slight tendency for agricultural output as a percentage of GDP to increase. Similarly, AGDP has a weak positive correlation of 0.1792 with EXR (Exchange Rate). This implies that as the exchange rate increases, there is a slight tendency for agricultural output as a percentage of GDP to increase.

In summary, the correlation matrix provides insights into the relationships between the variables. It shows that labor force participation rate and government expenditure as a percentage of GDP are positively correlated with agricultural output as a percentage of GDP in Nigeria. While, population growth, bank credit to agriculture, inflation rate, and exchange rate show weak correlations, indicating that other factors may have a more significant influence on agricultural output.

#### **4.2.2 Unit Root Test**

The pre-estimation technique used to examine the stationarity level of individual variables is the Augmented Dickey Fuller (ADF). It indicates whether the variables are stationary or non-stationary. This permits this study to determine the stationary level of the variable under study in order to suggest the appropriate technique to estimate the parameter coefficients. Intercept model is used to statistically find the

significance of the variables at 1%, 5% and 10% critical point at levels and first difference. Furthermore, it should be noted that the lag length for ascertaining this stationarity level of our variables as well as unit-root test is automatic and optimally chosen by the Schwarz-Bayesian Information Criterion (SIC). The results of the unit root tests for the variables are summarized in the table 4.3 below.

**Table 4.3 Summary of the ADF Test**

Variable Series	At Levels		At First Difference		Order of Integration
	ADF Test Statistics	Test Critical Values	ADF Test Statistics	Test Critical Values	
Agricultural Output as a Percentage of GDP (AGDP)	-2.5623	-3.6155	-6.9653	-3.6155***	I(1)
Deposit Money Bank Credit to Agriculture (DCA)	-1.4900	-3.6055	-6.0883	-3.6104***	I(1)
Growth of Population (POPG)	-1.3106	-3.6463	-4.7585	-3.6210***	I(1)
Labour Force Participation (LFP)	1.7076	-3.6104	-3.2777	-2.9389**	I(1)
Government Expenditure as a Percentage of GDP (GE)	-1.8645	-3.6104	-10.2329	-3.6104***	I(1)
Inflation (INF)	3.0091	-2.9369**			I(0)
Exchange Rate (EXR)	2.1688	-3.6104	-4.1205	-3.6155***	I(1)

**Note that; \*\*\*1%, \*\* 5%, level of significance** Calculated at trend and intercept and lag lengths selected automatically using the Schwarz Info Criterion. See results in appendix I for details

**Source:** Author's computation

The stationarity test results, summarized in table 4.3 shows that only INF was stationary at levels at 5% level of significance which suggest that at levels, the statistic of the variables is stationary and integrated of order zero, which imply that the variable converges to its long-run equilibrium or true mean at levels. While for other variables (AGDP, POPG, LFP, GE, DCA and EXR), as a result of their non stationarity at levels, they were subjected to further test at first difference where they were found to be stationary. Where AGDP, DCA, POPG, GE and EXR are stationary at 1% level of significance, LFP is stationary at 5% level of significance. The implication of this is that the statistic of the variable were stationary and integrated of the first order, hence a long-run equilibrium convergence.

### 4.3 Analysis of the Asymmetric Causal Relationship Between Population Growth and Food Production in Nigeria.

The first objective is to analyze the asymmetry causal relationship that exist between population growth and food production in Nigeria. The variables for this study were observed to be a mixture of  $I(0)$  and  $I(1)$ , as a result, the asymmetry causality will be tested based on the Toda-Yamamoto (TY) causality test. The TY causality estimation, requires an optimum lag length which in this study was obtained based on Akaike's Information Criterion (AIC) after running a VAR (2) model for the variables. From the VAR (2) result, the lag length criteria test was carried out. Based on the AIC, lag 7 was chosen as the optimal lag length as shown in table 4.4.

It is important to note here that this optimal lag length was obtained using three independent variables which are the positive change in population growth (POPG\_POS), negative change in population growth (POPG\_NEG) and labour force participation (LFP). This is because the estimates when all the independent variables are included is unreliable as a result of the presence of serial correlation which violates the assumption of independence of errors. The result of this estimates is reported in the appendix IIa. Therefore, this study proceed to estimate the asymmetry causality relationship between population growth and food production in Nigeria with food production measured by agricultural contribution to GDP (AGDP) as the dependent variable while the positive and negative change in population growth (POPG\_POS and POPG\_NEG) and Labour force participation are the independent variables.

**Table 4.4 Lag Order Selection**

Lag	LogL	LR	FPE	AIC	SC	HQ
-----	------	----	-----	-----	----	----

0	-12.60578	NA	3.22e-05	1.006411	1.187806	1.067445
1	138.1877	255.8920	9.19e-09	-7.162891	-6.255917	-6.857722
2	159.9792	31.69667	6.78e-09	-7.513889	-5.881335	-6.964584
3	180.4192	24.77577	5.86e-09	-7.782980	-5.424847	-6.989540
4	200.2398	19.22003	6.01e-09	-8.014535	-4.930823	-6.976960
5	239.4595	28.52343	2.40e-09	-9.421791	-5.612499	-8.140080
6	294.3396	26.60850	5.81e-10	-11.77816	-7.243285	-10.25231
7	445.4236	36.62643*	1.28e-12*	-19.96507*	-14.70462*	-18.19509*

**Source:** Author's computation

The model was further tested for serial correlation among the variables of study before proceeding to carry out the causality test. The diagnostic autocorrelation LM Test was carried out to test for serial correlation. The result as presented in table in table 4.5 the test statistic is not statistically significant, which provides evidence that the residuals are not autocorrelated.

**Table 4.5: Autocorrelation LM Test**

Lag	LRE* stat	df	Prob.	Rao F-stat	Df	Prob.
1	24.35973	16	0.0819	2.058932	(16, 6.7)	0.1738
2	29.94339	16	0.0183	3.301820	(16, 6.7)	0.0612
3	11.52948	16	0.7757	0.553834	(16, 6.7)	0.8434
4	27.79857	16	0.0334	2.763945	(16, 6.7)	0.0929
5	7.435279	16	0.9639	0.302570	(16, 6.7)	0.9766
6	15.29423	16	0.5032	0.861148	(16, 6.7)	0.6241
7	19.21664	16	0.2576	1.284729	(16, 6.7)	0.3893

**Source:** Author's computation

Having established the appropriateness of the estimation method, the asymmetry causality test based in the TY procedure was reported in the table 4.6 below which depict the asymmetric causal relationship between population growth and food production in Nigeria.

**Table 4.6 Asymmetric Causality Results based on TY Procedure**

Dependent Variables	Independent Variables					Direction of Causality
	AGDP	POPG_POS	POPG_NEG	LFP	All	
AGDP		26.9500**	12.5015***	24.4969***	40.0233**	POPG_POS, POPG_NEG, LFP→AGDP (one-way causality)
POPG_POS	17.3657***		42.7000***	34.0174**	125.1365***	AGDP, POPG_NEG, LFP → POPG_POS (one-way causality)
POPG_NEG	8.18581	8.77497		68.9087***	127.7467***	LFP→POPG_NEG (one-way causality)
LFP	6.7007	1.5772	6.1004		8.7668	No Causality

**Note that; \*\*\*1%, \*\* 5% and \* 10% level of significance**

**Source: Author's Computation**

From the results presented in table 4.6, it can be seen that the analysis indicates a significant bi-directional causal relationship between positive population growth and food production in Nigeria. This means that an increase in the population growth rate has a direct impact on food production, leading to higher levels of production. It suggests that population growth can be considered a driving force behind increased food production in Nigeria. However, as a result of the return causality, food production also leads to an expansion in population growth. Hence, policies aimed at increasing food production can contribute to population growth in Nigeria.

Meanwhile, there was found a significant one-way causality from negative population growth to food production in Nigeria. This result implies that a decline in population growth rate can cause changes in food production in Nigeria. It suggests that a decrease in population growth could potentially have significant effects on food production in Nigeria.

Labour force participation rate (LFP) on the other hand was found to also exhibit a one-way causality to food production in Nigeria. This implies that a larger labor force actively engaged in the agricultural sector leads to higher productivity and, consequently, increased agricultural output.

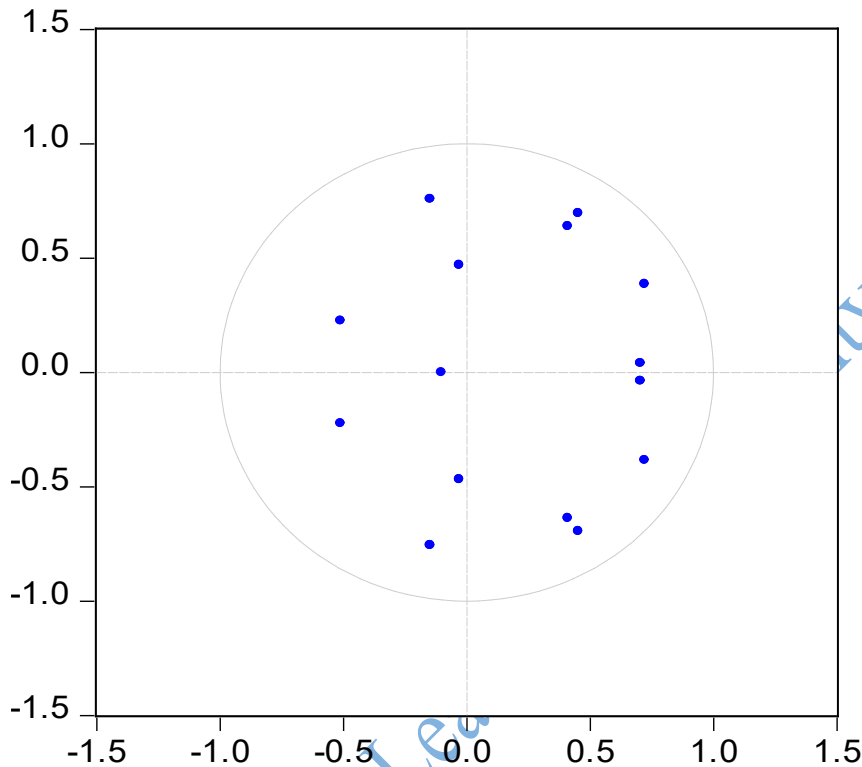
Furthermore, negative population growth (POPG\_NEG) was found to have a one-way causal relationship with positive population growth (POPG\_POS). This means that changes in negative population growth can influence subsequent changes in positive population growth.

It was also found a significant positive one-way causality from the labor force participation rate to positive population growth (POPG\_POS) and negative population growth (POPG\_NEG). This indicates that an increase in labor force participation positively influences both positive and negative population growth. A larger labor force actively participating in economic activities contributes to population dynamics in Nigeria.

Meanwhile, none of the independent variables (AGDP, POPG\_POS, POPG\_NEG) have a significant causal effect on the labor force participation rate (LFP). This indicate that changes in agricultural output or population growth do not significantly influence the labor force participation rate in the agricultural sector. It is important to note that the coefficient for LFP is not statistically significant, indicating no causal relationship. This implies that there are other factors responsible for changes in LFP which may include wages and salaries. Hence, policies aimed at increasing agricultural output or population growth may not directly impact the labor force participation rate in Nigeria.

The stability of the model is further tested using the inverse roots of the AR characteristic polynomial which provide insights into the persistence or decay of autocorrelation in the time series.

### Inverse Roots of AR Characteristic Polynomial



**Figure 4.4: Inverse Roots of AR Characteristic Polynomial**

Source: Author's Computation

As shown on the figure 4.4, the inverse roots of the AR characteristic polynomial have roots within the bounds, which indicates that the autoregressive process exhibits stable dynamics and that the autocorrelations decay exponentially over time. The stability condition ensures that the process remains well-behaved and avoids issues such as explosive growth or extreme fluctuations.

#### 4.4 Examination of the Asymmetric Effect of Population Growth on Food Production in Nigeria.

The second objective is to examine the asymmetric effect of population growth on food production in Nigeria. This is achieved by estimating the non-linear long run and short run dynamic interrelationship among the variables in the study using the

non-linear autoregressive distributed lag (ARDL) technique. This method is used as a result of the order of integration which was found to be a combination of I(0) and I(1) series. In view of this, the bound test for non-linear cointegration was conducted to determine long run relationship among the variables. The table 4.7 presents the result of the bound test for non-linear cointegration test.

**Table 4.7 Asymmetric Cointegration Test Results using NARDL Bound Test**

Test Statistic	F-Statistic	k	Remarks
$F_{agdp}(AGDP  POPG^+, POPG^-, LFP, DCA)$ NARDL Model (3, 4, 1, 3, 2)	12.0115	4	Cointegration
<b>Critical Value</b>	<b>10%</b>	<b>5%</b>	<b>2.5%</b>
<b>Bounds</b>	<b>I(0) Bound</b>	2.08	2.39
	<b>I(1) Bound</b>	3	3.38
			2.7
			3.73
			3.06
			4.15

**Source:** Author's computation

The table 4.7 shows the asymmetric long-run cointegration among the variables. The Akaike Information Criterion is used to select the appropriate lag structure of the NARDL framework (AIC). The results show that the F-statistics values in exceed the upper bound values at 1% critical levels for the asymmetric relationship between agricultural output as a percentage of GDP (AGDP) and growth of population (POPG) as well as other macroeconomic variables. Consequently, the null hypothesis is rejected, and it is concluded that the variables exhibit a non-linear long-run equilibrium cointegration relationship at the conventional level. Additionally, the NARDL bound results provide evidence of an asymmetric long-run relationship between food production and population growth in Nigeria. Given the identification of non-linear cointegration among the variables, tables 4.8 display the non-linear short-run and long-run estimates obtained using the NARDL estimator.

**Table 4.8: Short run and Long run Asymmetric Effect of Population Growth on Food Production in Nigeria.**

<b>Asymmetry Short Run Estimate</b>				
<b>Variable</b>	<b>Coefficient</b>	<b>Std. Error</b>	<b>t-Statistic</b>	<b>Prob.*</b>
<i>d</i> (AGDP(-1))	0.506451	0.087373	5.796400	0.0000
<i>d</i> (POPG_POS)	-115.8838	18.07491	-6.411308	0.0000
<i>d</i> (POPG_POS(-1))	79.52912	13.65879	5.822560	0.0000
<i>d</i> (POPG_POS(-2))	28.38271	7.535387	3.766589	0.0021
<i>d</i> (POPG_NEG)	76.85737	13.31264	5.773261	0.0000
<i>d</i> (POPG_NEG(-1))	45.56472	14.81785	3.074988	0.0082
<i>d</i> (POPG_NEG(-2))	-10.28262	11.52250	-0.892395	0.3873
<i>d</i> (POPG_NEG(-3))	44.47844	8.920784	4.985935	0.0002
<i>d</i> (LFP)	0.299307	0.358758	0.834288	0.4181
<i>d</i> (LFP(-1))	-0.280916	0.434268	-0.646871	0.5282
<i>d</i> (LFP(-2))	-0.856383	0.506494	-1.690806	0.1130
<i>d</i> (LFP(-3))	-0.905706	0.428630	-2.113027	0.0530
<i>d</i> (GE)	0.306104	0.114755	2.667454	0.0184
<i>d</i> (GE(-1))	-0.598477	0.136489	-4.384797	0.0006
<i>d</i> (GE(-2))	-0.685790	0.109446	-6.266003	0.0000
CoIntEq(-1)*	-1.091096	0.099555	-10.95970	0.0000
<b>Asymmetry Long Run Estimate</b>				
POPG_POS	-18.22941	9.054819	-2.013228	0.0637
POPG_NEG	-9.897564	6.259298	-1.581258	0.1361
LFP	-0.473185	0.482202	-0.981301	0.3431
DCA	-7.955490	2.677605	-2.971121	0.0101
GE	0.809691	0.403344	2.007446	0.0644
C	51.97615	31.95225	1.626682	0.1261
R-squared	0.9003	F-Statistics(Prob.)	10.3033(0.0000)	
Adjusted R-squared	0.8256	Durbin-Watson stat	3.12165	
<b>Diagnostic Tests</b>				
Serial Correlation	25.1016(0.0624)	Heteroskedasticity test	26.1874(0.1352)	
Normality Test	0.2144(0.8983)	Stability Test	Stable	

**Source:** Author's computation

Table 4.8 presents the result of the short run and long run asymmetry effect of population growth on food production in Nigeria between 1981 and 2021. From the results, it can be observed that in the short run, the coefficient of  $d(AGDP(-1))$  with a p-value  $< 0.01$  indicate that agricultural output as a percentage of GDP has a positive and statistically significant influence on itself at 1% level. This implies that a 1% increase in agricultural output as a percentage of GDP in the previous period leads to a 0.51% increase in the current period. This suggests that food production put plays a significant role in influencing itself in the short-run.

The positive change in population growth in the current period  $d(POPG\_POS)$  is found to have a negative and significant effect on food production in Nigeria at 1% level of significance. With the coefficient of -115.8838 it means that a positive shock in population growth which cause a positive change in the current period, leads to a decrease of 115.8838 units in food production. Meanwhile, the first and second lag of the positive change in population growth  $d(POPG\_POS(-1))$  and  $d(POPG\_POS(-2))$  both have positive and significant effect on food production in Nigeria at 1% level of significance. The implication of this is that a sudden increase in population growth in the past has will lead to increase in food production in the current period

The negative change in population growth in the current period  $d(POPG\_NEG)$  on the other hand is found to have a positive and significant effect on food production in Nigeria at 1% level of significance with a coefficient of 76.86 indicating that a negative shock in population growth in the current period leads to an increase of

76.86 units in the food production in the current period. This suggests that negative population growth shocks have a positive effect on food production in Nigeria. The first and third lag of the negative shock in population growth  $d(\text{POPG\_NEG}(-1))$  and  $d(\text{POPG\_NEG}(-3))$  were both found to have a positive and significant effect on food production in Nigeria at 1% level of significance. This means that unexpected reduction in the growth of population in the past will lead to an increase in food production in the present.

Only the third lag of labour force participation  $d(\text{LFP}(-3))$  was found to have a statistically significant effect on food production in Nigeria, exhibiting a negative effect at 10 percent level of significant. The implication of this is that an increase in labour force participation in the past will lead to a decline in food production in the present. With respect to government expenditure as a percentage of GDP, it was found that in the current period,  $d(\text{GE})$  has a positive and significant effect on food production in Nigeria at 5% level of significance, with a coefficient of 0.31 suggesting that a 1% increase in government expenditure leads to a 0.31% increase in food production in Nigeria. However, the first and second lag  $d(\text{GE}(-1))$  and  $d(\text{GE}(-2))$  were both found to have negative and significant effect on food production in Nigeria at 1% level of significance. The implication of this is that increase in past government expenditures as a percentage of GDP will lead to a reduction in food production in Nigeria.

The coefficient of  $\text{CointEq}(-1)^*$  is -1.091096. This coefficient represents the error correction term and reflects the speed of adjustment to long-run equilibrium. The t-statistic of -10.95970 indicates that this coefficient is statistically significant at a high level of confidence ( $p < 0.01$ ). It implies that deviations from the long-run equilibrium are corrected at a significant speed in the short run.

In summary, the short-run estimates provide evidence of various relationships between the variables. Positive population growth has a negative impact on agricultural output, while lagged positive and negative population growth have positive effects. Lagged agricultural output, government expenditure, and the lagged error correction term show positive relationships with agricultural output. The labor force participation rate does not demonstrate a statistically significant relationship with agricultural output in the short run. These findings contribute to our understanding of the nexus between population growth and food production in Nigeria.

In the long run as reported in the table 4.8, it was found that the positive shock of population growth POPG\_POS was found to have a negative and significant effect on food production in Nigeria at 10% level of significance, with a coefficient of -18.22941. This indicates that when the population growth rate increases, it puts pressure on the country's food production, potentially leading to a decrease in agricultural output. However, the p-value (0.0637) suggests that this result is marginally significant.

The negative shock of population growth POPG\_NEG on the other hand was found to have a negative and insignificant effect on food production in Nigeria. This suggests that a decline in population growth can somewhat alleviate the pressure on food production in Nigeria. However, the p-value (0.1361) indicates that this result is not statistically significant at conventional levels.

LFP (Labour Force Participation Rate) was found to have a negative but insignificant effect on food production in Nigerian indicating that labor force participation rate alone may not directly affect the relationship between population growth and food production. DCA (Deposit Money Bank Credit to Agriculture) on the other hand was

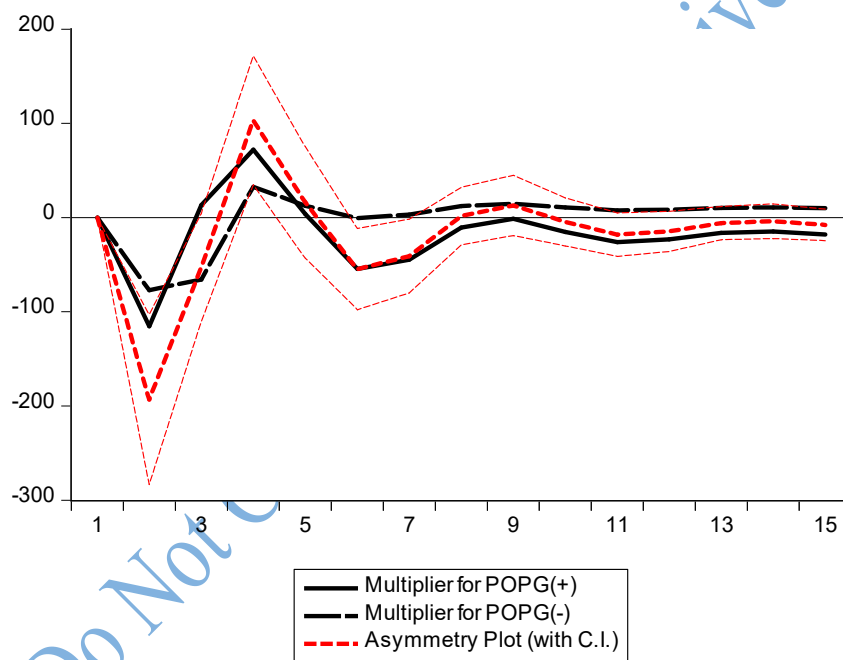
found to have a negative and significant effect on food production in Nigeria at 5% level of significance. This implies that greater access to credit for the agricultural sector can lead to higher agricultural output, which, in turn, can help alleviate the pressures caused by population growth on food production. While for GE (Government Expenditure as a Percentage of GDP), a positive and significant effect was discovered at 10% level of significance. This implies that higher government spending, particularly on initiatives related to agriculture and food production, can help mitigate the negative effects of population growth on agricultural output. However, the p-value (0.0644) indicates that this result is marginally significant.

In summary, the NARDL long-run results provide mixed evidence regarding the nexus between population growth and food production in Nigeria. While the negative population growth and labour force participation rate do not show a significant relationship with food production, deposit money bank credit to agriculture demonstrates a significant negative association. Meanwhile, positive population growth and government expenditure as a percentage of GDP appear to have marginally significant effects on food production in the long run.

Overall, the variables in the model, jointly explains 82.56% of the variation in food production in Nigeria considering the degree of freedom, however, the Durbin-Watson statistics of 3.12 shows that there is a presence of first order serial correlation in the model. The overall test using the F-statistic (10.3033) is statistically significant at 1% level of significance showing that model is well specified and statistically significant.

The diagnostic tests also shows that the residuals are normally distributed and that there is an absence of autocorrelation in the residuals, as the p-value for the test is greater than 0.05. The Breusch-Pagan-Godfrey heteroskedasticity test confirms that

there is no significant heteroskedasticity in the residuals, meaning that the mean and variance remain constant throughout the study period. These tests ensure the consistency of the model. The stability tests was also carried out using the Cumulative Sum of recursive residuals (CUSUM) and Cumulative Sum of recursive residual square (CUSUMSQ) tests. The graphical representation of the CUSUM and CUSUMSQ statistics is presented in the appendix. The results for CUSUM and CUSUMSQ statistics is presented in the appendix. The results for CUSUM and CUSUMSQ test results indicates the absence of any instability of the coefficients because the plot of the CUSUM and CUSUMSQ statistic fall inside the critical bands of the 95% confidence interval of parameter stability. By implication, this model is not suffering from structural change.



**Figure 4.5 Asymmetric Cumulative Dynamic Multiplier**  
**Source: Author's computation**

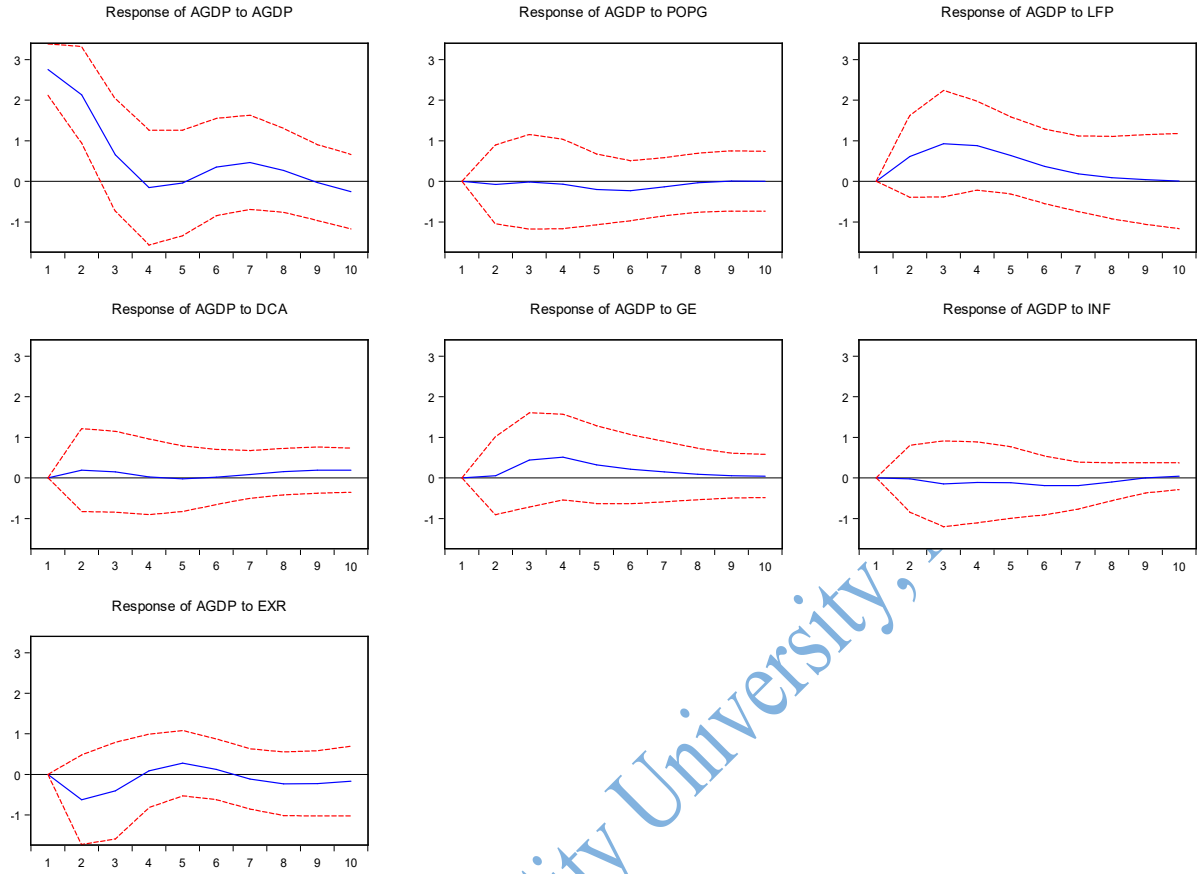
Figure 4.5 shows the asymmetric cumulative dynamic multiplier of the effect of population growth in food production in Nigeria. The black line shows the positive effect of population growth on food production, while the black dotted line shows the negative impact. The red tick line shows the asymmetry in short term and finally, the

dotted Red lines show the upper and the lower bounds of the asymmetry. This shows that the effect of shocks in population growth are only significant in the short run as food production returns to convergence in the long run.

#### **4.5 Analysis Result of the Assessment of the Response of Food Production to Shocks in Population Growth in Nigeria**

The third objective of this study is to assess the response of food production to shocks in population growth in Nigeria between 1981 and 2021. In order to achieve this, two econometric analysis was conducted, which are the impulse response function (IRF) and the variance decomposition analysis (VDA). The findings with respect to the mechanism through which food production (AGDP) respond to one-standard deviation of population growth (POPG), deposit money bank credit to agriculture (DCA), labour force participation rate (LFP), exchange rate (EXR), inflation rate (INF) and Government Expenditure as a Percentage of GDP (GE) are presented in figure 4.6 below. The Impulse Response Function (IRF) was generated from the unrestricted VAR model to trace the response of one endogenous variable (AGDP) to one standard shock in another variables.

Response to Cholesky One S.D. (d.f. adjusted) Innovations  $\pm 2$  S.E.



Do Not Copy, Lead City University,

#### **Figure 4.6: Impulse Response Function Graph of Food Production to Population Growth Shocks**

**Source:** Author's computation

The figure 4.6 depicts the impulse response function plot of food production to shocks from population growth and other macroeconomic indicators using a period of ten (10). The IRF analysis result revealed that the current agricultural output as a percentage of GDP (AGDP) respond negatively to one standard deviation shocks on itself from the initial period till the fifth period, after which it slopes upward till the eighth period and then decline till the tenth period. The implication of this is that unexpected changes in AGDP tend to have significant influence on changes in itself. Whereas, with regards to shocks in population growth (POPG), AGDP slightly respond negatively from the initial period and continue to increase till the seventh period after which it returns to convergence as the response of AGDP is relatively stable. This imply that food production only respond slightly to shocks in POPG over the periods.

As a result of shocks in labour force participation rate (LFP), AGDP responded with a significant increase from the initial period till the fourth period after which it decline till it converges in the eighth period and remained till the end of the period. This imply that LFP only have significant influence on changes in food production in the short term. Similarly, AGDP significantly respond positively to shocks in Government Expenditure as a Percentage of GDP (GE) till the fourth period, going further, the AGDP falls till it converges in the eighth period till the tenth period. It means that GE only have significant effect on the changes in food production in the short term in Nigeria.

Meanwhile, with respect to shocks in deposit money bank credit to agriculture (DCA) and inflation rate (INF), the response from food production shows slight negative

changes and a return to convergence as a return of unexpected changes in INF and the response from AGDP to unexpected changes in DCA is unstable in the with slight changes over the period ending with slight increase starting from the seventh period. This means that unexpected changes in inflation and deposit money bank credit to agriculture only have slight influence in changes in food production in Nigeria. In addition, food production responded negatively initially to shocks in exchange rate (EXR), then begin to rise from the third period till the fifth period after which it falls till the eight period while from there, it tends towards convergence. This means unexpected changes in EXR is responsible for changes in food production largely in the short term.

To complement the impulse response analysis, the variance decomposition test is carried out. While, the impulse reaction functions traced the effects of a shock to one endogenous variable on the other variables in the VAR, Variance Decomposition separates the variation in an endogenous variable into the component shocks of the VAR. Thus, the variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VAR system.

The table 4.9 shows the result of the variance decomposition test of the response of food production to shocks in population growth and other macroeconomic variables. The table presents separate variance decomposition for each endogenous variable. The second column, labeled "S.E", contains the forecast error of the variable at the given forecast period. The source of this forecast error was the variation in the current and future values of the shocks to each endogenous variable in the VAR. The other columns for each of the macroeconomic variables give the percentage of the forecast variance due to each shocks, with each row adding up to 100. Also, the forecast

period of 10 years is selected but split into short-run and long-run where 1 to 5 years is considered short-run while 6 through 10 years is the future or long-run

**Table 4.9 Result of Variance Decomposition Analysis**

Period	S.E.	AGDP	POPG	LFP	DCA	GE	INF	EXR
1	2.755387	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	3.599077	93.71034	0.043727	2.908378	0.291084	0.021668	0.003350	3.021449
3	3.826492	85.82263	0.040039	8.421079	0.415547	1.361658	0.150839	3.788210
4	3.965890	80.04763	0.066146	12.75399	0.390853	2.951290	0.218291	3.571807
5	4.045734	76.92877	0.309008	14.72347	0.377992	3.477035	0.291512	3.892210
6	4.096107	75.78785	0.623678	15.16778	0.371421	3.662262	0.498918	3.888099
7	4.138755	75.50915	0.718035	15.05755	0.406333	3.723374	0.700229	3.885324
8	4.160175	75.14975	0.717798	14.95040	0.539395	3.735099	0.746720	4.160835
9	4.171444	74.74952	0.714201	14.88038	0.748157	3.731337	0.742721	4.433682
10	4.187148	74.55611	0.708876	14.76917	0.946317	3.715374	0.746638	4.557511

Cholesky Ordering: AGDP POPG LFP DCA GE INF EXR

**Source:** Author's computation

The variance decomposition test result as presented in table 4.9 provides insights into the contribution of each variable to the overall variation in the dependent variable over time. In this case, the dependent variable is agricultural output as a percentage of GDP (AGDP), and the independent variables include population growth (POPG), labor force participation rate (LFP), deposit money bank credit to agriculture (DCA), government expenditure as a percentage of GDP (GE), inflation rate (INF), and exchange rate (EXR). The result shows that AGDP (Agricultural Output as a Percentage of GDP) In the first period, AGDP explains 100% of its own variance since no other variables are included yet. However, moving from the first period to the fifth period, the explanatory power of AGDP gradually declines, suggesting that

other variables are gaining importance in explaining agricultural output. Meanwhile, AGDP continues to be the dominant contributor to its own variance throughout the long run (from the sixth period). However, its explanatory power decreases compared to the short run, suggesting the increasing importance of other variables.

However, POPG (Growth of Population) on the other hand does not contribute to the variation in AGDP in the first period since its contribution is zero. Meanwhile, from the second period onwards, POPG starts to have a positive effect on AGDP. Its contribution gradually increases, indicating that population growth plays a role in explaining the variation in agricultural output. Although POPG plays a more substantial role in explaining the variation in AGDP during the long run as its contribution increases significantly compared to the short run, indicating that population growth has a stronger impact on agricultural output in the long term but the explanatory power of POPG is not significant because throughout the period, the percentage of variation in AGDP explained by POPG is less than 1%.

Similar to POPG, DCA (Deposit Money Bank Credit to Agriculture) and INF (Inflation Rate) both have negligible impact on AGDP their contribution to the variation in agricultural output remains below 1% throughout the ten periods. This implies that access to credit provided by deposit money banks and inflation both have a more prominent role in explaining agricultural output in the long term, although their contribution to the variation remain low.

Furthermore, LFP (Labour Force Participation Rate) does not influence AGDP during the first period, whereas from the second period onwards, LFP begins to contribute to the variation in AGDP, and its contribution increases over time. This suggests that the labor force participation rate has a significant impact on agricultural output. The contribution of LFP to the variation in AGDP remains significant as it explains up to

15% of the variation in AGDP during the long run. Its impact on agricultural output continues to increase, suggesting that a higher labor force participation rate significantly influence food production over time in Nigeria.

With regard to GE (Government Expenditure as a Percentage of GDP), during the short run, GE does not significantly affect AGDP. Its contributions to changes in food production is relatively low, however, the impact of GE on AGDP continue to grow during the long run, its contribution increases up to 3.7%, indicating that government expenditure explains about 3.7% of the changes in food production in Nigeria. Whereas, EXR (Exchange Rate) has a limited effect on AGDP in the short run. Its contribution is relatively low across the first five periods but continue to grow up to about 4.5% in the long run. The implication of this is that EXR contribute up to 4.5% of the changes in food production in Nigeria.

Overall, the variance decomposition results indicate that LFP, GE and EXR are important factors influencing food production in Nigeria. However, POPG, DCA and INF have relatively limited effects on food production in Nigeria.

#### **4.6 Discussion of Findings**

This study explored the interrelationships between Food Production and Population Growth in Nigeria using data from 1981 to 2021. The objective was to analyze the asymmetric causal relationship between population growth and food production, examine the asymmetric effect of population growth on food production and access the response of food production to shocks in population growth in Nigeria. Findings from the analysis provided some insight into the relationship that exist between population growth and food production in Nigeria.

The first objective analyzed the asymmetric causal relationship between population growth and food production in Nigeria. Findings from the analysis revealed several important findings regarding the relationship between population growth, food production, and labor force participation in Nigeria. Firstly, there is a significant bi-directional causality between positive population growth and food production, indicating that population growth has a direct impact on food production, and vice versa. Additionally, negative population growth has a one-way causal relationship with food production, suggesting that a decline in population growth can affect food production in Nigeria. Furthermore, the labor force participation rate exhibits a one-way causal relationship with food production, indicating that a larger labor force engaged in agriculture leads to higher productivity and increased agricultural output. Moreover, negative population growth influences subsequent changes in positive population growth, and an increase in labor force participation positively affects both positive and negative population growth. However, changes in agricultural output or population growth do not significantly influence the labor force participation rate, suggesting that other factors, such as wages and salaries, play a more significant role in determining labor force participation in the agricultural sector. Therefore, policies aimed at increasing agricultural output or population growth may not directly impact the labor force participation rate in Nigeria.

These findings are in line past studied that also examine the relationship between population growth, food production, and labor force participation in Nigeria. Firstly, a study found a significant bi-directional relationship between population growth and food production, emphasizing the positive impact of population growth on agricultural output<sup>1</sup>. Similarly, another study identified a strong positive association between population growth and agricultural productivity in Nigeria, highlighting the

role of population dynamics in driving food production<sup>2</sup>. Furthermore, other scholars have also demonstrated the positive impact of labor force participation on agricultural output, affirming the notion that an increased labor force in the agricultural sector leads to higher productivity and improved food production<sup>3</sup>.

In contrast, there are also studies that present opposing perspectives. One of such found no significant relationship between population growth and agricultural productivity in Nigeria. The study suggests that population growth alone does not directly translate into increased food production, indicating that other factors such as technology, infrastructure, and access to resources play a crucial role<sup>4</sup>. Similarly, another study argued that the impact of population growth on agricultural productivity is contingent on various socio-economic factors, such as education, access to credit, and agricultural policies<sup>5</sup>. The study highlighted the need for comprehensive and targeted interventions to maximize the potential benefits of population growth on food production. Additionally, scholars also found that labor force participation does not significantly influence agricultural output in Nigeria, contradicting the notion of a strong positive relationship between the two variables<sup>6</sup>.

The second objective was to examine the asymmetric effect of population growth on food production in Nigeria. This was analyzed using the NARDL model. The result shows that the short-run estimates provide evidence of various relationships between the variables. Positive population growth has a negative impact on agricultural output, while lagged positive and negative population growth have positive effects. Lagged agricultural output, government expenditure, and the lagged error correction term show positive relationships with agricultural output. The labor force participation rate does not demonstrate a statistically significant relationship with agricultural output in the short run. These findings contribute to our understanding of the nexus between

population growth and food production in Nigeria. In the long run however, the results shows that while the negative population growth and labour force participation rate do not show a significant relationship with food production, deposit money bank credit to agriculture demonstrates a significant negative association. Meanwhile, positive population growth and government expenditure as a percentage of GDP appear to have marginally significant effects on food production in the long run.

This results supported by some studies that explore similar area such as a study which found an increase in population growth negatively affects food production in Nigeria. This align with the current analysis, which also demonstrates a negative impact of positive population growth on agricultural output<sup>7</sup>. Similarly, another study supports the positive effects of lagged population growth on food production, indicating that past population growth shocks influence current agricultural output positively<sup>8</sup>. Furthermore, others also observed a positive relationship between government expenditure and agricultural output in Nigeria, which is consistent with the current analysis that highlights the positive relationship between government expenditure and food production<sup>9</sup>.

On the other hand, there are other studies with contrasting findings. For instance, a study argues that population growth does not significantly impact agricultural output in Nigeria. This contradict the current analysis, which reveals a negative impact of positive population growth on food production<sup>10</sup>. Additionally, another study suggests that the labor force participation rate positively affects agricultural output, contrary to the current analysis that does not find a statistically significant relationship between labor force participation and food production in Nigeria<sup>11</sup>. Moreover, scholars also challenges the positive relationship between government expenditure and agricultural

output, indicating that government expenditure does not significantly influence food production in Nigeria, in contrast to the findings of the present analysis<sup>12</sup>.

The third objective was to assess the response of food production to shocks in population growth in Nigeria. This was analysed using the impulse response function and variance decomposition. The impulse response function analysis reveals that food production in Nigeria is sensitive to shocks in various macroeconomic indicators. Agricultural output as a percentage of GDP (AGDP) responds negatively to unexpected changes in itself, with a gradual increase and subsequent decline over time. Shocks in population growth (POPG) have a slight negative impact on food production, with a relatively stable response. The labor force participation rate (LFP) positively influences food production in the short term, while government expenditure as a percentage of GDP (GE) shows a positive effect in the short term but declines over time. Unexpected changes in deposit money bank credit to agriculture (DCA), inflation rate (INF), and exchange rate (EXR) have slight to moderate effects on food production in Nigeria, with varying response patterns.

It was also found from the variance decomposition test that the contribution of various variables to the variation in agricultural output as a percentage of GDP (AGDP) in Nigeria. AGDP itself initially explains 100% of its own variance but gradually decreases in explanatory power over time, suggesting the growing importance of other variables. Population growth (POPG) has a positive effect on AGDP, although its contribution remains below 1% throughout the period, indicating a relatively weak impact. Deposit money bank credit to agriculture (DCA) and inflation rate (INF) also have negligible effects on AGDP, with their contributions remaining below 1%. In contrast, the labor force participation rate (LFP) shows a significant impact on AGDP, with its contribution increasing over time and explaining up to 15% of the variation in

AGDP during the long run. Government expenditure as a percentage of GDP (GE) and exchange rate (EXR) have limited effects on AGDP in the short run, but their contributions increase in the long run, with GE explaining about 3.7% and EXR contributing up to 4.5% of the changes in food production in Nigeria.

Past studies have also supported these findings. Studies have found a positive shocks in population growth negatively affect agricultural output, indicating a similar response pattern<sup>13, 14</sup>. Additionally, another study examined the impact of population growth on agricultural productivity in Nigeria and reported a negative relationship between population growth and food production, aligning with the present analysis<sup>15</sup>. Furthermore, a study investigated the nexus between population growth and agricultural productivity in Nigeria and highlighted the significance of labor force participation, similar to the current findings<sup>16</sup>.

Meanwhile, other studies differ in their findings. For instance, a study examined the relationship between population growth and agricultural productivity in Nigeria and found a positive relationship between population growth and food production, contrasting the negative impact observed in the current analysis<sup>17</sup>. Similarly, another study explored the nexus between population growth and agricultural output in Nigeria and reported a positive relationship, contrary to the negative influence observed in the present study<sup>18</sup>. Additionally, some other scholars also investigated the impact of population growth on agricultural productivity in Nigeria and found no significant relationship between the variables, differing from the significant effects observed in the current analysis<sup>19</sup>.

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## Chapter Five

### Conclusion

#### 5.0 Preamble

This chapter presents the summary of major findings and conclusion. Recommendations were also offered based on the findings and areas for further studies were also suggested.

#### 5.1 Summary of Findings

The production of food that is sufficient enough to meet the demands of the growing population in Nigeria has been a growing concern. This study therefore explored the relationship that exists between population growth and food production in Nigeria. The specific objectives were to analyze the asymmetric causal relationship between population growth and food production, examine the asymmetric effect of population growth on food production and assess the response of food production to shocks in population growth in Nigeria. This was done using secondary time series data from 1981 to 2021 sourced from world bank development index (WDI) and CBN statistical bulletin.

The data was subjected to statistical tests starting with the descriptive statistics which provides the properties of the data used for the analysis, it was found that agriculture contributes an average of approximately 22.87% to the country's GDP, with moderate variability and a slightly right-skewed distribution. The population growth rate averages around 2.62%, showing relatively low variability and a right-skewed distribution. The labor force participation rate stands at 58.26%, with moderate variability and a slightly left-skewed distribution. Deposit money bank credit to agriculture averages 0.59%, exhibiting a moderate range and a slightly left-skewed

distribution. Government expenditure contributes around 8.45% to GDP, with moderate variability and a slightly left-skewed distribution. The average inflation rate is approximately 19.00%, indicating significant variability and a right-skewed distribution. The exchange rate averages 100.76 Nigerian Naira per unit of another currency, showing considerable variability and a slightly right-skewed distribution. These findings provide valuable insights into the economic landscape of Nigeria. The correlation matrix provides insights into the relationships between the variables. It shows that labor force participation rate and government expenditure as a percentage of GDP are positively correlated with agricultural output as a percentage of GDP in Nigeria. While, population growth, bank credit to agriculture, inflation rate, and exchange rate show weak correlations, indicating that other factors may have a more significant influence on agricultural output. The ADF test of stationarity shows that the variables in this study are stationary at level and at first difference.

With regards to the objectives, different methods were used to estimate each objective. The asymmetry causality test based on Toda Yamamoto method was used to estimate the first objective, the second objective was achieved using the non linear ARDL (NARDL) method while the third objective was achieved using a combination of impulse response function and variance decomposition. Using these methods, the findings provides some insights into the relationship between population growth, food production, and labor force participation in Nigeria.

Findings from the first objective shows that there is a significant bi-directional causality between positive population growth and food production, indicating that population growth has a direct impact on food production, and vice versa. Additionally, negative population growth has a one-way causal relationship with food production, suggesting that a decline in population growth can affect food production

in Nigeria. Furthermore, the labor force participation rate exhibits a one-way causal relationship with food production, indicating that a larger labor force engaged in agriculture leads to higher productivity and increased agricultural output. Moreover, negative population growth influences subsequent changes in positive population growth, and an increase in labor force participation positively affects both positive and negative population growth. However, changes in agricultural output or population growth do not significantly influence the labor force participation rate, suggesting that other factors, such as wages and salaries, play a more significant role in determining labor force participation in the agricultural sector. Therefore, policies aimed at increasing agricultural output or population growth may not directly impact the labor force participation rate in Nigeria.

The second objective was to examine the asymmetric effect of population growth on food production in Nigeria. The result shows that the short-run estimates provide evidence of various relationships between the variables. Positive population growth has a negative impact on agricultural output, while lagged positive and negative population growth have positive effects. Lagged agricultural output, government expenditure, and the lagged error correction term show positive relationships with agricultural output. The labor force participation rate does not demonstrate a statistically significant relationship with agricultural output in the short run. These findings contribute to our understanding of the nexus between population growth and food production in Nigeria. In the long run however, the results shows that while the negative population growth and labour force participation rate do not show a significant relationship with food production, deposit money bank credit to agriculture demonstrates a significant negative association. Meanwhile, positive population

growth and government expenditure as a percentage of GDP appear to have marginally significant effects on food production in the long run.

From the third objective, the impulse response function analysis reveals that food production in Nigeria is sensitive to shocks in various macroeconomic indicators. Agricultural output as a percentage of GDP (AGDP) responds negatively to unexpected changes in itself, with a gradual increase and subsequent decline over time. Shocks in population growth (POPG) have a slight negative impact on food production, with a relatively stable response. The labor force participation rate (LFP) positively influences food production in the short term, while government expenditure as a percentage of GDP (GE) shows a positive effect in the short term but declines over time. Unexpected changes in deposit money bank credit to agriculture (DCA), inflation rate (INF), and exchange rate (EXR) have slight to moderate effects on food production in Nigeria, with varying response patterns.

It was also found from the variance decomposition test that the contribution of various variables to the variation in agricultural output as a percentage of GDP (AGDP) in Nigeria. AGDP itself initially explains 100% of its own variance but gradually decreases in explanatory power over time, suggesting the growing importance of other variables. Population growth (POPG) has a positive effect on AGDP, although its contribution remains below 1% throughout the period, indicating a relatively weak impact. Deposit money bank credit to agriculture (DCA) and inflation rate (INF) also have negligible effects on AGDP, with their contributions remaining below 1%. In contrast, the labor force participation rate (LFP) shows a significant impact on AGDP, with its contribution increasing over time and explaining up to 15% of the variation in AGDP during the long run. Government expenditure as a percentage of GDP (GE) and exchange rate (EXR) have limited effects on AGDP in the short run, but their

contributions increase in the long run, with GE explaining about 3.7% and EXR contributing up to 4.5% of the changes in food production in Nigeria.

The findings of the study highlight the significant relationships between population growth, labor force participation rate, and food production in Nigeria. Positive population growth has a direct impact on food production, while negative population growth influences food production negatively. Additionally, the labor force participation rate positively affects food production in the short term. However, other factors such as deposit money bank credit to agriculture, inflation rate, and exchange rate also play a role in influencing food production in Nigeria.

## **5.2 Conclusion**

In conclusion, this study sheds light on the complex relationship between population growth and food production in Nigeria. The findings indicate that population growth has a significant impact on food production, both positively and negatively, emphasizing the need for sustainable population management strategies. The labor force participation rate is also found to be a key factor affecting agricultural output, highlighting the importance of promoting employment and productivity in the agricultural sector. However, the study reveals that other factors such as access to credit, inflation, and exchange rates also influence food production, suggesting the necessity of comprehensive policies that consider these multifaceted dynamics.

The results further demonstrate the asymmetrical effects of population growth on food production in Nigeria, with positive population growth having a negative short-term impact on agricultural output but positive effects in the long run. Moreover, the study highlights the sensitivity of food production to shocks in various macroeconomic

indicators, emphasizing the importance of economic stability and effective policy responses to maintain food security.

While population growth and its relationship with food production are complex, this study provides valuable insights for policymakers and stakeholders. It underscores the need for holistic approaches that address population dynamics, labor force participation, access to credit, inflation, and exchange rates to foster sustainable food production in Nigeria. By considering these findings, policymakers can develop targeted strategies that promote agricultural productivity, ensure employment opportunities, and mitigate the challenges associated with population growth, ultimately contributing to food security and economic development in the country.

### **5.3 Recommendations**

Based on the findings of the study, the following recommendations can be made to policymakers and stakeholders in Nigeria:

1. Conduct a comparative analysis of three developing countries within a specific region to assess the effectiveness of integrated healthcare, education, and family planning programs in relation to their impact on agricultural productivity and stable population growth over the past decade.
2. Conduct a longitudinal study across diverse agricultural regions to analyze the correlation between the implementation of targeted skill development programs and the retention rates of agricultural workers over a five-year period. Investigate how varying wage structures, benefits, and working conditions influence the stability and productivity of the labor force within the agricultural sector
3. Conduct a comparative analysis of two regions—one with significant government investment in modern farming technologies and another without—assessing the

impact on agricultural productivity over a ten-year period. Explore the correlation between increased funding for agricultural R&D, improved infrastructure, and the implementation of financial support mechanisms on food production sustainability and resilience in the face of population growth

4. Conduct a cross-national analysis of government agricultural expenditure policies in three different economic landscapes, exploring the nuances of the impact of specific types of support (e.g., direct subsidies, budgetary allocations, market facilitation policies) on agricultural productivity over a 15-year period. Investigate the correlation between various forms of government support and their effectiveness in fostering sustainable long-term food production, considering factors like market access, technological advancements, and farm-level profitability.
5. Conduct a comprehensive analysis of the impact of inflation and exchange rate fluctuations on the agricultural sector in Nigeria over the last two decades, employing econometric models to quantify the specific thresholds or tipping points at which these economic variables significantly affect different segments of the agricultural supply chain. Investigate how targeted interventions such as price stabilization mechanisms and market regulations influence the resilience of agricultural production during periods of inflation spikes or currency volatility, ultimately assessing their role in fostering sustained agricultural investment and output.
6. Conduct a comparative case study analysis of two countries—one with a highly collaborative multi-stakeholder approach in the agricultural sector and another with limited collaboration—exploring the impact of diverse collaborative models on agricultural productivity and sustainable development over a ten-year period.

Assess the mechanisms, structures, and levels of engagement among government agencies, agricultural associations, research institutions, and other stakeholders, evaluating how effective collaboration influences policy implementation, knowledge exchange, and the resolution of multifaceted challenges within the agricultural domain. Additionally, investigate the role and impact of international partnerships and donor involvement in enhancing agricultural strategies and outcomes.

#### **5.4 Contribution to Knowledge**

The findings presented in this study make significant contribution to our understanding of the relationship between population growth and food production in Nigeria. The study provides valuable insights into the causal dynamics between these variables, highlighting the direct impact of positive population growth on food production and the influence of negative population growth on agricultural output. Moreover, the study emphasizes the positive effect of a larger labor force engaged in agriculture on productivity and agricultural output. By examining the asymmetric effects of population growth on food production, the study reveals the complex nature of this relationship in both the short and long run. Additionally, the analysis of the response of food production to shocks in various macroeconomic indicators including inflation and exchange rate sheds light on the sensitivity of the agricultural sector to fluctuations in population growth, labor force participation, government expenditure, credit availability, inflation, and exchange rates. Overall, these findings contribute to the existing body of knowledge on the intricate interplay between population growth and food production, providing valuable insights for policymakers, researchers, and stakeholders in Nigeria's agricultural sector.

### **5.5 Area of Further Research**

Further research could investigate how technological advancements, such as mechanization, irrigation systems, and improved farming practices, interact with population growth and labor force participation to influence food production. Understanding the impact of technology on agricultural productivity could provide valuable insights into strategies for increasing food production and ensuring food security in Nigeria.

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## Appendices

### Appendix I: Pre-Estimation Tests

#### I.I Descriptive Statistics

	AGDP	POPG	LFP	DCA	GE	INF	EXR
Mean	22.86948	2.623292	58.25893	0.586783	8.445272	18.99895	100.7601
Median	22.07050	2.608257	60.26350	0.548487	8.150014	12.71577	106.4643
Maximum	36.96508	3.002988	60.67300	1.003945	17.28619	72.83550	358.8108
Minimum	12.24041	2.440609	52.40000	0.162611	5.089349	5.388008	0.617708
Std. Dev.	4.647603	0.119017	2.716736	0.222546	2.552236	16.86848	100.7283
Skewness	0.442825	0.942310	-0.702821	0.166767	1.495011	1.823489	0.888717
Kurtosis	4.624443	4.189591	1.869109	2.243555	5.740249	5.159022	2.994774
Jarque-Bera	5.705318	8.278198	5.424571	1.139090	27.41532	29.93637	5.265499
Probability	0.057691	0.015937	0.066385	0.565783	0.000001	0.000000	0.071881
Sum	914.7793	104.9317	2330.357	23.47131	337.8109	759.9580	4030.406
Sum Sq.							
Dev.	842.4082	0.552435	287.8455	1.931539	254.0424	11097.27	395701.7
Observations	40	40	40	40	40	40	40

#### I.II Correlation

	AGDP	POPG	LFP	DCA	GE	INF	EXR
AGDP	1.00000						
POPG	-0.152038	1.000000					
LFP	0.662755	-0.006752	1.000000				
DCA	-0.146345	-0.424861	0.083102	1.000000			
GE	0.252134	-0.055937	0.569515	0.373159	1.000000		
INF	0.050035	-0.208236	0.244971	0.519562	0.221625	1.000000	
EXR	0.179252	-0.209330	-0.319029	-0.511202	-0.427600	-0.341823	1.000000

#### I.III Unit Root Test

##### AGDP

##### *At Level*

Null Hypothesis: AGDP has a unit root

Exogenous: Constant

Lag Length: 2 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.562353	0.1096
Test critical values:		
1% level	-3.615588	
5% level	-2.941145	
10% level	-2.609066	

\*MacKinnon (1996) one-sided p-values.

**At First Difference**

Null Hypothesis:  $d(\text{AGDP})$  has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-6.965308	0.0000
Test critical values:		
1% level	-3.615588	
5% level	-2.941145	
10% level	-2.609066	

\*MacKinnon (1996) one-sided p-values.

**DCA**

**Level**

Null Hypothesis: DCA has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.490023	0.5283
Test critical values:		
1% level	-3.605593	
5% level	-2.936942	
10% level	-2.606857	

\*MacKinnon (1996) one-sided p-values.

***At First Difference***

Null Hypothesis: D(DCA) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-6.088303	0.0000
Test critical values:		
1% level	-3.610453	
5% level	-2.938987	
10% level	-2.607932	

\*MacKinnon (1996) one-sided p-values.

**POPG**

**At Level**

Null Hypothesis: POPG has a unit root

Exogenous: Constant

Lag Length: 7 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.310623	0.6129
Test critical values:		
1% level	-3.646342	
5% level	-2.954021	
10% level	-2.615817	

\*MacKinnon (1996) one-sided p-values.

***At First Difference***

Null Hypothesis: D(POPG) has a unit root

Exogenous: Constant

Lag Length: 2 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-4.758562	0.0004
Test critical values:		
1% level	-3.621023	
5% level	-2.943427	
10% level	-2.610263	

\*MacKinnon (1996) one-sided p-values.

**LFP****At Level**

Null Hypothesis: LFP has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.707631	0.4196
Test critical values:		
1% level	-3.610453	
5% level	-2.938987	
10% level	-2.607932	

\*MacKinnon (1996) one-sided p-values.

**At First Difference**Null Hypothesis:  $d(LFP)$  has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.277711	0.0229
Test critical values:		
1% level	-3.610453	
5% level	-2.938987	
10% level	-2.607932	

\*MacKinnon (1996) one-sided p-values.

**INF****At Level**

Null Hypothesis: INF has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.009107	0.0426
Test critical values:		
1% level	-3.605593	
5% level	-2.936942	
10% level	-2.606857	

\*MacKinnon (1996) one-sided p-values.

**GE****At Level**

Null Hypothesis: GE has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.864578	0.3450
Test critical values:		
1% level	-3.610453	
5% level	-2.938987	
10% level	-2.607932	

\*MacKinnon (1996) one-sided p-values.

**At First Difference**Null Hypothesis:  $d(\text{GE})$  has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-10.23291	0.0000
Test critical values:		
1% level	-3.610453	
5% level	-2.938987	
10% level	-2.607932	

\*MacKinnon (1996) one-sided p-values.

**EXR****Level**

Null Hypothesis: EXR has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	2.168856	0.9999
Test critical values:		
1% level	-3.610453	
5% level	-2.938987	
10% level	-2.607932	

\*MacKinnon (1996) one-sided p-values.

**At First Difference**

Null Hypothesis:  $d(\text{EXR})$  has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-4.120537	0.0026
Test critical values:		
1% level	-3.615588	
5% level	-2.941145	
10% level	-2.609066	

\*MacKinnon (1996) one-sided p-values.

**LIV Lag Selection**

VAR Lag Order Selection Criteria

Endogenous variables: AGDP POPG LFP DCA GE

INF EXR

Exogenous variables: C

Date: 06/09/23 Time: 16:19

Sample: 1981 2021

Included observations: 36

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-530.5269	NA	21972.88	29.86260	30.17051	29.97007
1	-368.1791	252.5411	42.65515	23.56550	26.02875	24.42524
2	-313.5560	63.72689	43.19655	23.25311	27.87171	24.86513
3	-191.0293	95.29852	2.008324	19.16830	25.94224	21.53258
		79.77204	0.006415	10.49451	19.42380	13.61107
4	14.09879	*	*	*	*	*

\* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

### **I.III Unit Root Test**

#### **AGDP**

##### ***At Level***

Null Hypothesis: AGDP has a unit root

Exogenous: Constant

Lag Length: 2 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.562353	0.1096
Test critical values:		
1% level	-3.615588	
5% level	-2.941145	
10% level	-2.609066	

\*MacKinnon (1996) one-sided p-values.

##### ***At First Difference***

Null Hypothesis:  $d(\text{AGDP})$  has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-6.965308	0.0000
Test critical values:		
1% level	-3.615588	
5% level	-2.941145	
10% level	-2.609066	

\*MacKinnon (1996) one-sided p-values.

#### **DCA**

##### **Level**

Null Hypothesis: DCA has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.490023	0.5283
Test critical values:		
1% level	-3.605593	
5% level	-2.936942	
10% level	-2.606857	

\*MacKinnon (1996) one-sided p-values.

***At First Difference***

Null Hypothesis:  $d$ (DCA) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-6.088303	0.0000
Test critical values:		
1% level	-3.610453	
5% level	-2.938987	
10% level	-2.607932	

\*MacKinnon (1996) one-sided p-values.

**POPG**

**At Level**

Null Hypothesis: POPG has a unit root

Exogenous: Constant

Lag Length: 7 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.310623	0.6129
Test critical values:		
1% level	-3.646342	
5% level	-2.954021	
10% level	-2.615817	

\*MacKinnon (1996) one-sided p-values.

***At First Difference***

Null Hypothesis:  $d$ (POPG) has a unit root

Exogenous: Constant

Lag Length: 2 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-4.758562	0.0004
Test critical values:		
1% level	-3.621023	
5% level	-2.943427	
10% level	-2.610263	

\*MacKinnon (1996) one-sided p-values.

**LFP****At Level**

Null Hypothesis: LFP has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.707631	0.4196
Test critical values:		
1% level	-3.610453	
5% level	-2.938987	
10% level	-2.607932	

\*MacKinnon (1996) one-sided p-values.

**At First Difference**Null Hypothesis:  $d(LFP)$  has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.277711	0.0229
Test critical values:		
1% level	-3.610453	
5% level	-2.938987	
10% level	-2.607932	

\*MacKinnon (1996) one-sided p-values.

**INF****At Level**

Null Hypothesis: INF has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.009107	0.0426
Test critical values:		
1% level	-3.605593	
5% level	-2.936942	
10% level	-2.606857	

\*MacKinnon (1996) one-sided p-values.

## GE

### At Level

Null Hypothesis: GE has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.864578	0.3450
Test critical values:		
1% level	-3.610453	
5% level	-2.938987	
10% level	-2.607932	

\*MacKinnon (1996) one-sided p-values.

### At First Difference

Null Hypothesis:  $d(\text{GE})$  has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-10.23291	0.0000
Test critical values:		
1% level	-3.610453	
5% level	-2.938987	
10% level	-2.607932	

\*MacKinnon (1996) one-sided p-values.

## EXR

### Level

Null Hypothesis: EXR has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	2.168856	0.9999
Test critical values:		
1% level	-3.610453	
5% level	-2.938987	
10% level	-2.607932	

\*MacKinnon (1996) one-sided p-values.

**At First Difference**

Null Hypothesis:  $d(\text{EXR})$  has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-4.120537	0.0026
Test critical values:		
1% level	-3.615588	
5% level	-2.941145	
10% level	-2.609066	

\*MacKinnon (1996) one-sided p-values.

**I.IV Lag Selection**

VAR Lag Order Selection Criteria

Endogenous variables: AGDP POPG LFP DCA GE

INF EXR

Exogenous variables: C

Date: 06/09/23 Time: 16:19

Sample: 1981 2021

Included observations: 36

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-530.5269	NA	21972.88	29.86260	30.17051	29.97007
1	-368.1791	252.5411	42.65515	23.56550	26.02875	24.42524
2	-313.5560	63.72689	43.19655	23.25311	27.87171	24.86513
3	-191.0293	95.29852	2.008324	19.16830	25.94224	21.53258
		79.77204	0.006415	10.49451	19.42380	13.61107
4	14.09879	*	*	*	*	*

\* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

## Appendix IIa

### Objective One: Result of the Asymmetric Causal Relationship Between Population Growth and Food Production in Nigeria.

#### I VAR Result

Vector Autoregression Estimates

Date: 06/15/23 Time: 13:00

Sample (adjusted): 1984 2021

Included observations: 38 after adjustments

Standard errors in ( ) & t-statistics in [ ]

	AGDP	POPG_PO S	POPG_NE G	DCA	LFP	GE
AGDP(-1)	0.792716 (0.17905) [ 4.42727]	0.000874 (0.00147) [ 0.59492]	0.001945 (0.00137) [ 1.42201]	-0.010326 (0.00686) [-1.50610]	0.025220 (0.04245) [ 0.59409]	-0.105999 (0.13016) [-0.81435]
AGDP(-2)	-0.390236 (0.19090) [-2.04417]	-0.002191 (0.00157) [-1.39810]	-0.000787 (0.00146) [-0.53949]	-0.004709 (0.00731) [-0.64419]	0.031663 (0.04526) [ 0.69957]	0.093067 (0.13878) [ 0.67061]
POPG_POS(-1)	12.60917 (13.7937) [ 0.91413]	0.219256 (0.11323) [ 1.93636]	-0.391396 (0.10536) [-3.71474]	0.475476 (0.52816) [ 0.90025]	-1.450842 (3.27031) [-0.44364]	-5.975510 (10.0275) [-0.59591]
POPG_POS(-2)	-13.60746 (14.3471) [-0.94844]	0.398977 (0.11777) [ 3.38766]	0.238689 (0.10959) [ 2.17801]	-0.708513 (0.54935) [-1.28973]	1.165888 (3.40152) [ 0.34276]	-9.045523 (10.4298) [-0.86728]
POPG_NEG(-1)	-22.89362 (14.6072) [-1.56728]	0.615488 (0.11991) [ 5.13298]	0.981736 (0.11158) [ 8.79874]	0.177171 (0.55931) [ 0.31677]	3.316450 (3.46317) [ 0.95763]	-7.715261 (10.6189) [-0.72656]
POPG_NEG(-2)	12.27599 (10.4221) [ 1.17788]	-0.645998 (0.08555) [-7.55081]	-0.098287 (0.07961) [-1.23462]	-0.324615 (0.39906) [-0.81345]	-1.442411 (2.47094) [-0.58375]	-4.079470 (7.57644) [-0.53844]
DCA(-1)	2.585635 (4.99465) [ 0.51768]	-0.099556 (0.04100) [-2.42817]	-0.028918 (0.03815) [-0.75798]	0.549627 (0.19124) [ 2.87394]	-0.886113 (1.18417) [-0.74830]	-1.253164 (3.63092) [-0.34514]
DCA(-2)	-1.548664 (4.90836) [-0.31552]	-0.086953 (0.04029) [-2.15807]	-0.037740 (0.03749) [-1.00659]	0.171373 (0.18794) [ 0.91185]	1.266854 (1.16371) [ 1.08864]	2.061052 (3.56818) [ 0.57762]
LFP(-1)	1.014326 (0.76090) [ 1.33306]	-0.011377 (0.00625) [-1.82149]	0.013696 (0.00581) [ 2.35636]	-0.026839 (0.02913) [-0.92121]	1.198695 (0.18040) [ 6.64465]	0.453834 (0.55315) [ 0.82046]

LFP(-2)	-0.083770 (0.77657) [-0.10787]	-0.000782 (0.00637) [-0.12267]	-0.009347 (0.00593) [-1.57567]	0.014557 (0.02973) [0.48958]	-0.440843 (0.18411) [-2.39441]	0.156763 (0.56453) [0.27769]
GE(-1)	-0.089430 (0.27020) [-0.33097]	0.001526 (0.00222) [0.68813]	0.000113 (0.00206) [0.05469]	0.010318 (0.01035) [0.99732]	0.038122 (0.06406) [0.59509]	0.019134 (0.19643) [0.09741]
GE(-2)	0.029619 (0.26318) [0.11254]	0.005012 (0.00216) [2.32006]	0.001247 (0.00201) [0.62032]	0.003506 (0.01008) [0.34793]	0.034450 (0.06240) [0.55211]	0.109380 (0.19132) [0.57171]
C	-49.53514 (28.5102) [-1.73745]	0.980996 (0.23404) [4.19164]	-0.296835 (0.21777) [-1.36304]	1.101403 (1.09165) [1.00893]	13.76156 (6.75939) [2.03592]	-31.78593 (20.7258) [-1.53364]
R-squared	0.678816	0.986488	0.989836	0.865373	0.956144	0.621344
Adj. R-squared	0.524647	0.980002	0.984957	0.800752	0.935093	0.439589
Sum sq. resids	179.4420	0.012092	0.010470	0.263083	10.08648	94.83010
S.E. equation	2.679119	0.021993	0.020464	0.102583	0.635184	1.947615
F-statistic	4.403075	152.0975	202.8799	13.39152	45.42089	3.418583
Log likelihood	-83.41272	99.08382	101.8204	40.56491	-28.71825	-71.29518
Akaike AIC	5.074354	-4.530727	-4.674756	-1.450785	2.195697	4.436588
Schwarz SC	5.634580	-3.970500	-4.114530	-0.890558	2.755924	4.996815
Mean dependent	23.61586	0.457403	-0.857006	0.598821	58.53161	8.485703
S.D. dependent	3.885832	0.155518	0.166851	0.229816	2.493192	2.601656
Determinant resid covariance (dof adj.)		1.50E-08				
Determinant resid covariance		1.22E-09				
Log likelihood		66.45609				
Akaike information criterion		0.607574				
Schwarz criterion		3.968935				
Number of coefficients		78				

### Lag length

VAR Lag Order Selection Criteria

Endogenous variables: AGDP POPG\_POS POPG\_NEG DCA

LFP GE

Exogenous variables: C

Date: 06/15/23 Time: 13:01

Sample: 1981 2021

Included observations: 36

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-142.0863	NA	0.000151	8.227019	8.490939	8.319134
1	74.53510	349.0012*	6.81e-09*	-1.807506	0.039933*	-1.162700*
2	98.51115	30.63606	1.58e-08	-1.139508	2.291450	-0.057988
3	144.9453	43.85451	1.47e-08	-1.719185	3.295292	0.031002
4	191.4727	28.43340	2.81e-08	-2.304039*	4.293956	-0.001162

\* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

### Toda Yamamoto Causality

Vector Autoregression Estimates

Date: 06/15/23 Time: 13:03

Sample (adjusted): 1985 2017

Included observations: 33 after adjustments

Standard errors in ( ) & t-statistics in [ ]

	AGDP	POPG_PO S	POPG_NE G	DCA	LFP	GE
AGDP(-1)	0.232517 (0.26981) [ 0.86179]	-0.000117 (0.00119) [-0.09869]	-0.001626 (0.00362) [-0.44944]	-0.019939 (0.01248) [-1.59770]	-6.43E-05 (0.08343) [-0.00077]	-0.010990 (0.34703) [-0.03167]
AGDP(-2)	-0.471086 (0.19084) [-2.46843]	0.000232 (0.00084) [ 0.27576]	0.000998 (0.00256) [ 0.38975]	0.004815 (0.00883) [ 0.54546]	0.014513 (0.05901) [ 0.24593]	0.009729 (0.24547) [ 0.03964]
AGDP(-3)	-0.018280 (0.24234) [-0.07543]	0.000443 (0.00107) [ 0.41593]	-0.001919 (0.00325) [-0.59051]	-0.026728 (0.01121) [-2.38450]	-0.027248 (0.07493) [-0.36362]	-0.114841 (0.31170) [-0.36844]

POPG_POS(-1)	55.61903 (30.2641) [ 1.83779]	0.627205 (0.13315) [ 4.71034]	-0.130166 (0.40593) [-0.32066]	-0.244046 (1.39986) [-0.17434]	-7.611950 (9.35803) [-0.81341]	-42.93052 (38.9263) [-1.10287]
POPG_POS(-2)	10.81510 (16.1461) [ 0.66983]	0.232808 (0.07104) [ 3.27719]	0.337295 (0.21657) [ 1.55747]	0.031006 (0.74683) [ 0.04152]	3.607655 (4.99256) [ 0.72261]	2.701951 (20.7674) [ 0.13011]
POPG_POS(-3)	-28.88007 (15.7473) [-1.83397]	-0.097278 (0.06928) [-1.40404]	-0.141377 (0.21122) [-0.66935]	-0.870469 (0.72838) [-1.19507]	3.122528 (4.86924) [ 0.64128]	7.262019 (20.2544) [ 0.35854]
POPG_NEG(-1)	1.560427 (24.2023) [ 0.06447]	0.306133 (0.10648) [ 2.87491]	1.146443 (0.32462) [ 3.53162]	0.436426 (1.11947) [ 0.38985]	-2.131268 (7.48363) [-0.28479]	-2.240347 (31.1294) [ 0.07197]
POPG_NEG(-2)	-45.18872 (32.1441) [-1.40582]	-0.627889 (0.14143) [-4.43969]	-0.661818 (0.43115) [-1.53502]	-0.909160 (1.48681) [-0.61148]	4.255094 (9.93935) [ 0.42811]	18.32190 (41.3443) [ 0.44315]
POPG_NEG(-3)	40.91033 (25.4633) [ 1.60664]	0.417769 (0.11203) [ 3.72901]	0.286370 (0.34154) [ 0.83848]	-0.518761 (1.17779) [-0.44045]	-7.453410 (7.87355) [-0.94664]	-38.21590 (32.7513) [-1.16685]
DCA(-1)	8.240689 (5.32335) [ 1.54803]	-0.055255 (0.02342) [-2.35917]	-0.020029 (0.07140) [-0.28052]	0.039637 (0.24623) [ 0.16098]	-2.075505 (1.64604) [-1.26090]	-0.876170 (6.84699) [-0.12796]
DCA(-2)	9.020000 (5.92563) [ 1.52220]	-0.047106 (0.02607) [-1.80683]	0.029277 (0.07948) [ 0.36836]	0.324251 (0.27409) [ 1.18302]	0.366695 (1.83227) [ 0.20013]	-4.372396 (7.62165) [-0.57368]
DCA(-3)	2.470772 (6.33579) [ 0.38997]	-0.006321 (0.02788) [-0.22676]	-0.003533 (0.08498) [-0.04157]	-0.049677 (0.29306) [-0.16951]	0.398031 (1.95910) [ 0.20317]	5.236114 (8.14921) [ 0.64253]
LFP(-1)	1.596356 (0.89170) [ 1.79025]	-0.005760 (0.00392) [-1.46821]	0.010097 (0.01196) [ 0.84424]	0.020804 (0.04125) [ 0.50440]	1.135972 (0.27572) [ 4.11997]	0.037431 (1.14692) [ 0.03264]
LFP(-2)	-0.712978 (1.19782) [-0.59523]	-0.003067 (0.00527) [-0.58203]	0.008849 (0.01607) [ 0.55080]	-0.008055 (0.05540) [-0.14538]	-0.897356 (0.37038) [-2.42280]	0.091932 (1.54065) [ 0.05967]

LFP(-3)	0.453973 (0.89064) [ 0.50971]	0.000341 (0.00392) [ 0.08700]	-0.009837 (0.01195) [-0.82344]	0.028783 (0.04120) [ 0.69867]	0.349766 (0.27540) [ 1.27004]	-0.302786 (1.14556) [-0.26431]
GE(-1)	-0.204218 (0.30525) [-0.66902]	0.004880 (0.00134) [ 3.63393]	0.001576 (0.00409) [ 0.38492]	-0.001118 (0.01412) [-0.07920]	0.018581 (0.09439) [ 0.19687]	-0.422903 (0.39261) [-1.07714]
GE(-2)	-0.327131 (0.25668) [-1.27446]	0.006750 (0.00113) [ 5.97710]	-0.000766 (0.00344) [-0.22261]	-0.012130 (0.01187) [-1.02164]	0.055129 (0.07937) [ 0.69458]	0.224813 (0.33015) [ 0.68094]
GE(-3)	0.177810 (0.35236) [ 0.50463]	0.006209 (0.00155) [ 4.00529]	-0.002207 (0.00473) [-0.46689]	-0.023111 (0.01630) [-1.41801]	0.032620 (0.10895) [ 0.29939]	-0.118212 (0.45321) [-0.26083]
C	-67.14507 (84.0338) [-0.79902]	0.726717 (0.36973) [ 1.96554]	-0.677781 (1.12714) [-0.60133]	-4.568974 (3.88695) [-1.17546]	48.29509 (25.9842) [ 1.85863]	85.66226 (108.086) [ 0.79254]
AGDP(4)	0.180841 (0.18826) [ 0.96060]	-0.000433 (0.00083) [-0.52300]	-0.001098 (0.00253) [-0.43482]	-0.010412 (0.00871) [-1.19570]	-0.017213 (0.05821) [-0.29570]	0.181700 (0.24214) [ 0.75039]
POPG_POS(4)	23.74418 (22.5120) [ 1.05474]	0.333191 (0.09905) [ 3.36396]	0.008706 (0.30195) [ 0.02883]	-1.235642 (1.04128) [-1.18665]	-5.044249 (6.96097) [-0.72465]	-16.62994 (28.9553) [-0.57433]
POPG_NEG(4)	25.95768 (14.6221) [ 1.77524]	0.057916 (0.06433) [ 0.90024]	0.107316 (0.19612) [ 0.54718]	-1.201526 (0.67634) [-1.77652]	10.31413 (4.52132) [ 2.28122]	7.007162 (18.8072) [ 0.37258]
DCA(4)	-5.341796 (7.47016) [-0.71508]	0.081058 (0.03287) [ 2.46625]	-0.017373 (0.10020) [-0.17339]	-0.365847 (0.34553) [-1.05880]	0.071069 (2.30986) [ 0.03077]	-8.174954 (9.60825) [-0.85083]
LFP(4)	-0.007626 (0.70925) [-0.01075]	-0.005136 (0.00312) [-1.64575]	0.001582 (0.00951) [ 0.16632]	0.061590 (0.03281) [ 1.87741]	-0.255916 (0.21931) [-1.16692]	-0.675161 (0.91225) [-0.74011]
GE(4)	-0.078264 (0.32755) [-0.23894]	0.001706 (0.00144) [ 1.18373]	0.001253 (0.00439) [ 0.28519]	-0.013976 (0.01515) [-0.92243]	-0.017085 (0.10128) [-0.16869]	-0.583570 (0.42130) [-1.38515]

R-squared	0.943030	0.998995	0.988664	0.966222	0.978608	0.783528
Adj. R-squared	0.772120	0.995981	0.954656	0.864890	0.914433	0.134112
Sum sq. resids	29.56118	0.000572	0.005318	0.063246	2.826404	48.90473
S.E. equation	1.922277	0.008458	0.025783	0.088914	0.594391	2.472467
F-statistic	5.517697	331.4242	29.07169	9.535157	15.24908	1.206511
Log likelihood	-45.00922	134.0555	97.27158	56.41937	-6.276183	-53.31552
Akaike AIC	4.242983	-6.609426	-4.380096	-1.904204	1.895526	4.746395
Schwarz SC	5.376701	-5.475708	-3.246378	-0.770486	3.029244	5.880113
Mean dependent	23.89345	0.450741	-0.827521	0.594224	59.14847	8.794120
S.D. dependent	4.026825	0.133409	0.121082	0.241895	2.031983	2.657049

Determinant resid covariance (dof adj.)	2.97E-10
Determinant resid covariance	6.03E-14
Log likelihood	221.2946
Akaike information criterion	-4.320884
Schwarz criterion	2.481423
Number of coefficients	150

### Asymmetric Causality

VAR Granger Causality/Block Exogeneity Wald Tests

Date: 06/15/23 Time: 13:58

Sample: 1981 2021

Included observations: 33

Dependent variable: AGDP

Excluded	Chi-sq	Df	Prob.
POPG_POS	12.48025	3	0.0059
POPG_NEG	9.045637	3	0.0287
DCA	15.97358	3	0.0011
LFP	7.105876	3	0.0686
All	27.99533	12	0.0055

Dependent variable: POPG\_POS

Excluded	Chi-sq	Df	Prob.
AGDP	0.498391	3	0.9192
POPG_NEG	11.48884	3	0.0094
DCA	1.435891	3	0.6971
LFP	0.578529	3	0.9013
All	30.85715	12	0.0021

Dependent variable: POPG\_NEG

Excluded	Chi-sq	Df	Prob.
AGDP	0.308973	3	0.9583
POPG_POS	3.819951	3	0.2816
DCA	0.266081	3	0.9663
LFP	2.984908	3	0.3940
All	17.34454	12	0.1371

Dependent variable: DCA

Excluded	Chi-sq	Df	Prob.
AGDP	5.275152	3	0.1527
POPG_POS	3.011554	3	0.3898
POPG_NEG	2.293297	3	0.5138
LFP	0.315953	3	0.9570
All	19.23621	12	0.0830

Dependent variable: LFP

Excluded	Chi-sq	df	Prob.
AGDP	0.622141	3	0.8913
POPG_POS	1.935240	3	0.5860
POPG_NEG	4.068506	3	0.2542
DCA	2.776819	3	0.4273
All	11.75277	12	0.4657

### Serial Correlation Test

VAR Residual Portmanteau Tests for Autocorrelations  
Null Hypothesis: No residual autocorrelations up to lag h  
Date: 06/19/23 Time: 09:42  
Sample: 1981 2021  
Included observations: 38

Lags	Q-Stat	Prob.*	Adj Q-Stat	Prob.*	df
1	60.32263	---	61.95297	---	---
2	117.4467	---	122.2506	---	---
3	182.4398	0.0000	192.8146	0.0000	64
4	246.0049	0.0000	263.8579	0.0000	128

\*Test is valid only for lags larger than the VAR lag order.  
df is degrees of freedom for (approximate) chi-square distribution

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## Appendix IIb

### Objective One Reported

#### Optimal Lag Length

VAR Lag Order Selection Criteria

Endogenous variables: AGDP POPG\_NEG POPG\_POS

DCA

Exogenous variables: C

Date: 06/17/23 Time: 18:40

Sample: 1981 2021

Included observations: 33

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-12.60578	NA	3.22e-05	1.006411	1.187806	1.067445
1	138.1877	255.8920	9.19e-09	-7.162891	-6.255917	-6.857722
2	159.9792	31.69667	6.78e-09	-7.513889	-5.881335	-6.964584
3	180.4192	24.77577	5.86e-09	-7.782980	-5.424847	-6.989540
4	200.2398	19.22003	6.01e-09	-8.014535	-4.930823	-6.976960
5	239.4595	28.52343	2.40e-09	-9.421791	-5.612499	-8.140080
6	294.3396	26.60850	5.81e-10	-11.77816	-7.243285	-10.25231
7	445.4236	36.62643*	1.28e-12*	-19.96507*	-14.70462*	-18.19509*

\* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

### Asymmetry Causality - VAR Output

Vector Autoregression Estimates

Date: 06/17/23 Time: 20:06

Sample (adjusted): 1987 2015

Included observations: 29 after adjustments

Standard errors in ( ) & t-statistics in [ ]

	AGDP	POPG_POS	POPG_NEG	LFP
AGDP(-1)	-0.598676 (0.30410) [-1.96866]	-0.001810 (0.00113) [-1.60232]	-0.001634 (0.00152) [-1.07182]	-0.004104 (0.13011) [-0.03154]
AGDP(-2)	-1.270692 (0.23697) [-5.36216]	9.26E-05 (0.00088) [ 0.10521]	-0.002132 (0.00119) [-1.79445]	-0.056488 (0.10139) [-0.55713]
AGDP(-3)	-1.236400 (0.37785) [-3.27223]	0.001342 (0.00140) [ 0.95611]	-0.003589 (0.00189) [-1.89414]	-0.057101 (0.16166) [-0.35321]
AGDP(-4)	-0.974399 (0.35133) [-2.77343]	-0.000650 (0.00131) [-0.49797]	-0.002963 (0.00176) [-1.68167]	-0.324407 (0.15032) [-2.15811]
AGDP(-5)	-0.929143 (0.47669) [-1.94915]	-0.001359 (0.00177) [-0.76740]	-0.004606 (0.00239) [-1.92686]	-0.476645 (0.20396) [-2.33701]
POPG_POS(-1)	-158.6302 (59.8785) [-2.64920]	1.143763 (0.22245) [ 5.14174]	0.278083 (0.30026) [ 0.92615]	2.050089 (25.6193) [ 0.08002]
POPG_POS(-2)	271.4191 (74.1370) [ 3.66105]	-0.398297 (0.27542) [-1.44616]	-0.514265 (0.37176) [-1.38334]	18.21128 (31.7199) [ 0.57413]
POPG_POS(-3)	-115.4100 (45.5856) [-2.53172]	0.520316 (0.16935) [ 3.07244]	0.453398 (0.22859) [ 1.98349]	-17.64618 (19.5040) [-0.90475]

POPG_POS(-4)	-8.262353 (21.6585) [-0.38148]	-0.141406 (0.08046) [-1.75746]	-0.047767 (0.10860) [-0.43982]	-5.598491 (9.26667) [-0.60415]
POPG_POS(-5)	76.27459 (25.8354) [ 2.95233]	-0.615221 (0.09598) [-6.41004]	0.011647 (0.12955) [ 0.08990]	2.012536 (11.0538) [ 0.18207]
POPG_NEG(-1)	-63.05796 (43.7219) [-1.44225]	-0.357245 (0.16243) [-2.19944]	-0.090015 (0.21924) [-0.41057]	-37.60751 (18.7066) [-2.01038]
POPG_NEG(-2)	-113.3388 (65.0255) [-1.74299]	-0.791996 (0.24157) [-3.27857]	-0.563037 (0.32607) [-1.72676]	-38.03463 (27.8215) [-1.36710]
POPG_NEG(-3)	-80.07879 (57.8261) [-1.38482]	-0.418600 (0.21482) [-1.94859]	-0.316333 (0.28997) [-1.09094]	-27.01531 (24.7411) [-1.09192]
POPG_NEG(-4)	75.79713 (57.2501) [ 1.32397]	-1.108015 (0.21268) [-5.20972]	-0.060387 (0.28708) [-0.21035]	-5.182885 (24.4947) [-0.21159]
POPG_NEG(-5)	-72.61562 (30.6018) [-2.37292]	0.615212 (0.11368) [ 5.41156]	0.404843 (0.15345) [ 2.63825]	-4.945490 (13.0931) [-0.37772]
LFP(-1)	1.646603 (1.42463) [ 1.15581]	-0.000823 (0.00529) [-0.15549]	0.015134 (0.00714) [ 2.11854]	0.447778 (0.60953) [ 0.73462]
LFP(-2)	1.518598 (3.38560) [ 0.44855]	0.024496 (0.01258) [ 1.94761]	0.030074 (0.01698) [ 1.77145]	1.804493 (1.44854) [ 1.24573]
LFP(-3)	3.760362 (2.43260) [ 1.54582]	-0.002809 (0.00904) [-0.31087]	0.018437 (0.01220) [ 1.51150]	-0.128673 (1.04080) [-0.12363]
LFP(-4)	-7.409434 (5.24010) [-1.41399]	0.045992 (0.01947) [ 2.36261]	-0.048008 (0.02628) [-1.82707]	-1.832127 (2.24200) [-0.81718]
LFP(-5)	-4.246249 (5.41437) [-0.78426]	-0.063389 (0.02011) [-3.15144]	-0.018402 (0.02715) [-0.67780]	-0.305726 (2.31656) [-0.13197]

C	302.3720 (175.186) [ 1.72601]	-0.082486 (0.65081) [-0.12674]	0.319803 (0.87846) [ 0.36405]	202.5929 (74.9541) [ 2.70289]
POPG_POS(6)	71.14269 (61.9337) [ 1.14869]	-0.579466 (0.23008) [-2.51852]	0.070373 (0.31056) [ 0.22660]	-37.02177 (26.4986) [-1.39712]
POPG_NEG(6)	127.6038 (42.7466) [ 2.98512]	0.070668 (0.15880) [ 0.44501]	0.504729 (0.21435) [ 2.35469]	48.58830 (18.2893) [ 2.65665]
LFP(6)	-0.351462 (2.39534) [-0.14673]	-0.020017 (0.00890) [-2.24948]	-0.013544 (0.01201) [-1.12764]	-2.497005 (1.02486) [-2.43645]

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R-squared	0.976759	0.999689	0.998721	0.977034
Adj. R-squared	0.869853	0.998256	0.992837	0.871390
Sum sq. resids	9.853703	0.000136	0.000248	1.803815
S.E. equation	1.403831	0.005215	0.007039	0.600636
F-statistic	9.136570	698.0084	169.7266	9.248403
Log likelihood	-25.49721	136.7689	128.0704	-0.877034
Akaike AIC	3.413601	-7.777168	-7.177268	1.715658
Schwarz SC	4.545156	-6.645613	-6.045712	2.847213
Mean dependent	24.49676	0.452875	-0.825362	59.61016
S.D. dependent	3.891324	0.124897	0.083172	1.674844
Determinant resid covariance (dof adj.)	4.53E-11			
Determinant resid covariance	4.00E-14			
Log likelihood	282.7141			
Akaike information criterion	-12.87684			
Schwarz criterion	-8.350617			
Number of coefficients	96			

#### Asymmetric Causality Based on Toda Yamamoto

VAR Granger Causality/Block Exogeneity Wald Tests

Date: 06/17/23 Time: 19:03

Sample: 1981 2021

Included observations: 29

Dependent variable: AGDP

Excluded	Chi-sq	df	Prob.
POPG_NEG	12.50148	5	0.0285
POPG_POS	26.95009	5	0.0001
LFP	24.49690	5	0.0002
All	40.02328	15	0.0004

Dependent variable: POPG\_NEG

Excluded	Chi-sq	df	Prob.
AGDP	8.185808	5	0.1463
POPG_POS	8.774972	5	0.1184
LFP	68.90870	5	0.0000
All	127.7467	15	0.0000

Dependent variable: POPG\_POS

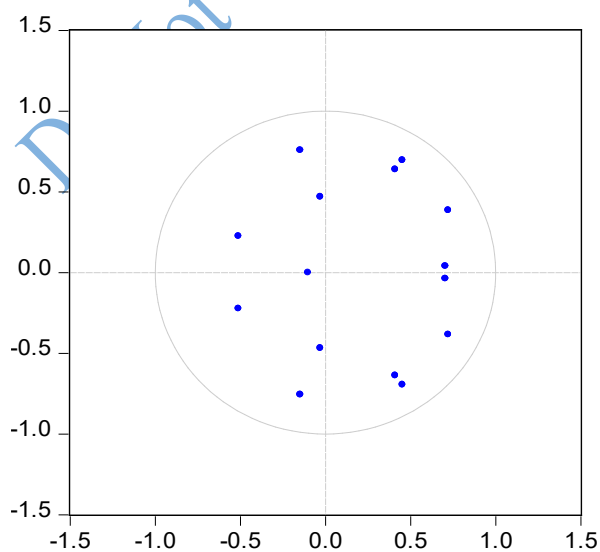
Excluded	Chi-sq	df	Prob.
AGDP	17.36577	5	0.0039
POPG_NEG	42.70001	5	0.0000
LFP	34.01744	5	0.0000
All	125.1365	15	0.0000

Dependent variable: LFP

Excluded	Chi-sq	df	Prob.
AGDP	6.700737	5	0.2439
POPG_NEG	6.100483	5	0.2966
POPG_POS	1.577241	5	0.9040
All	8.766887	15	0.8894

### Post Estimation Test

Inverse Roots of AR Characteristic Polynomial



## Autocorrelation LM Test

VAR Residual Serial Correlation LM Tests

Date: 06/19/23 Time: 10:40

Sample: 1981 2021

Included observations: 34

Null hypothesis: No serial  
correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	24.35973	16	0.0819	2.058932	(16, 6.7)	0.1738
2	29.94339	16	0.0183	3.301820	(16, 6.7)	0.0612
3	11.52948	16	0.7757	0.553834	(16, 6.7)	0.8434
4	27.79857	16	0.0334	2.763945	(16, 6.7)	0.0929
5	7.435279	16	0.9639	0.302570	(16, 6.7)	0.9766
6	15.29423	16	0.5032	0.861148	(16, 6.7)	0.6241
7	19.21664	16	0.2576	1.284729	(16, 6.7)	0.3893

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**Appendix III**  
**Objective Two: Result of the Asymmetric Effect of Population Growth on Food Production in Nigeria.**

**ARDL Result**

Dependent Variable: AGDP

Method: ARDL

Date: 06/12/23 Time: 23:37

Sample (adjusted): 1985 2021

Included observations: 37 after adjustments

Maximum dependent lags: 4 (Automatic selection)

Model selection method: Akaike info criterion (AIC)

Dynamic regressors (4 lags, automatic): POPG LFP DCA GE

Fixed regressors: C

Number of models evaluated: 2500

Selected Model: ARDL(2, 4, 0, 0, 4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
AGDP(-1)	0.392599	0.145153	2.704729	0.0129
AGDP(-2)	-0.445906	0.127101	-3.508282	0.0020
POPG	9.254381	7.979709	1.159739	0.2586
POPG(-1)	5.307504	9.508002	0.558214	0.5823
POPG(-2)	-12.20672	8.715436	-1.400587	0.1753
POPG(-3)	-2.589822	6.927644	-0.373839	0.7121
POPG(-4)	-20.23388	5.488415	-3.686652	0.0013
LFP	0.086793	0.253114	0.342900	0.7349
DCA	-7.308366	2.251352	-3.246212	0.0037
GE	0.092923	0.175638	0.529063	0.6021
GE(-1)	-0.318814	0.172398	-1.849295	0.0779
GE(-2)	-0.272881	0.174646	-1.562479	0.1324
GE(-3)	0.653028	0.157685	4.141347	0.0004
GE(-4)	0.358193	0.183818	1.948625	0.0642
C	73.80168	16.13109	4.575121	0.0001
R-squared	0.881422	Mean dependent var		23.75930
Adjusted R-squared	0.805964	S.D. dependent var		3.836077
S.E. of regression	1.689775	Akaike info criterion		4.178003
Sum squared resid	62.81746	Schwarz criterion		4.831078
Log likelihood	-62.29306	Hannan-Quinn criter.		4.408243
F-statistic	11.68088	Durbin-Watson stat		2.123059
Prob(F-statistic)	0.000000			

\*Note: p-values and any subsequent tests do not account for model selection.

## NARDL Result

Dependent Variable: AGDP

Method: ARDL

Date: 06/12/23 Time: 23:40

Sample (adjusted): 1986 2021

Included observations: 36 after adjustments

Maximum dependent lags: 4 (Automatic selection)

Model selection method: Akaike info criterion (AIC)

Dynamic regressors (4 lags, automatic): POPG\_POS POPG\_NEG LFP

DCA GE

Fixed regressors: C

Number of models evaluated: 12500

Selected Model: ARDL(2, 3, 4, 4, 0, 3)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
AGDP(-1)	0.415356	0.118952	3.491801	0.0036
AGDP(-2)	-0.506451	0.113807	-4.450104	0.0005
POPG_POS	-115.8838	36.15206	-3.205455	0.0064
POPG_POS(-1)	175.5229	42.99738	4.082177	0.0011
POPG_POS(-2)	-51.14641	20.88545	-2.448902	0.0281
POPG_POS(-3)	-28.38271	10.51019	-2.700494	0.0172
POPG_NEG	76.85737	23.37879	3.287482	0.0054
POPG_NEG(-1)	-42.09184	29.03206	-1.449840	0.1691
POPG_NEG(-2)	-55.84734	29.27804	-1.907482	0.0772
POPG_NEG(-3)	54.76107	22.97375	2.383636	0.0319
POPG_NEG(-4)	-44.47844	13.50859	-3.292605	0.0053
LFP	0.299307	0.527518	0.567388	0.5794
LFP(-1)	-1.096513	0.870402	-1.259778	0.2283
LFP(-2)	-0.575468	1.011141	-0.569127	0.5783
LFP(-3)	-0.049323	1.030321	-0.047871	0.9625
LFP(-4)	0.905706	0.620756	1.459037	0.1666
DCA	-8.680200	3.208847	-2.705084	0.0171
GE	0.306104	0.191304	1.600094	0.1319
GE(-1)	-0.021131	0.209474	-0.100877	0.9211
GE(-2)	-0.087312	0.173978	-0.501859	0.6236
GE(-3)	0.685790	0.156161	4.391557	0.0006
C	56.71094	35.73057	1.587183	0.1348
R-squared	0.939228	Mean dependent var		23.91296
Adjusted R-squared	0.848070	S.D. dependent var		3.773245
S.E. of regression	1.470741	Akaike info criterion		3.887171
Sum squared resid	30.28312	Schwarz criterion		4.854877
Log likelihood	-47.96908	Hannan-Quinn criter.		4.224926
F-statistic	10.30332	Durbin-Watson stat		3.121653
Prob(F-statistic)	0.000027			

\*Note: p-values and any subsequent tests do not account for model selection.

### NARDL Long Run and Bound Test

ARDL Long Run Form and Bounds Test

Dependent Variable:  $d(AGDP)$

Selected Model: ARDL(2, 3, 4, 4, 0, 3)

Case 2: Restricted Constant and No Trend

Date: 06/12/23 Time: 23:29

Sample: 1981 2021

Included observations: 36

#### Conditional Error Correction Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	56.71094	35.73057	1.587183	0.1348
AGDP(-1)*	-1.091096	0.135942	-8.026209	0.0000
POPG_POS(-1)	-19.89003	9.845013	-2.020315	0.0629
POPG_NEG(-1)	-10.79919	6.691296	-1.613916	0.1289
LFP(-1)	-0.516290	0.530619	-0.972996	0.3471
DCA**	-8.680200	3.208847	-2.705084	0.0171
GE(-1)	0.883450	0.461602	1.913880	0.0763
$d(AGDP(-1))$	0.506451	0.113807	4.450104	0.0005
$d(POPG\_POS)$	-115.8838	36.15206	-3.205455	0.0064
$d(POPG\_POS(-1))$	79.52912	19.42729	4.093680	0.0011
$d(POPG\_POS(-2))$	28.38271	10.51019	2.700494	0.0172
$d(POPG\_NEG)$	76.85737	23.37879	3.287482	0.0054
$d(POPG\_NEG(-1))$	45.56472	19.03736	2.393437	0.0313
$d(POPG\_NEG(-2))$	-10.28262	18.06292	-0.569267	0.5782
$d(POPG\_NEG(-3))$	44.47844	13.50859	3.292605	0.0053
$d(LFP)$	0.299307	0.527518	0.567388	0.5794
$d(LFP(-1))$	-0.280916	0.592835	-0.473852	0.6429
$d(LFP(-2))$	-0.856383	0.623700	-1.373069	0.1913
$d(LFP(-3))$	-0.905706	0.620756	-1.459037	0.1666
$d(GE)$	0.306104	0.191304	1.600094	0.1319
$d(GE(-1))$	-0.598477	0.248389	-2.409432	0.0303
$d(GE(-2))$	-0.685790	0.156161	-4.391557	0.0006

\* p-value incompatible with t-Bounds distribution.

\*\* Variable interpreted as  $Z = Z(-1) + D(Z)$ .

Levels Equation  
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
POPG_POS	-18.22941	9.054819	-2.013228	0.0637
POPG_NEG	-9.897564	6.259298	-1.581258	0.1361
LFP	-0.473185	0.482202	-0.981301	0.3431
DCA	-7.955490	2.677605	-2.971121	0.0101
GE	0.809691	0.403344	2.007446	0.0644
C	51.97615	31.95225	1.626682	0.1261

$$EC = AGDP - (-18.2294 * POPG\_POS - 9.8976 * POPG\_NEG - 0.4732 * LFP - 7.9555 * DCA + 0.8097 * GE + 51.9761)$$

F-Bounds Test Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
Asymptotic: n=1000				
F-statistic	12.01150	10%	2.08	3
K	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	3.06	4.15
		Finite Sample: n=40		
Actual Sample Size	36	10%	2.306	3.353
		5%	2.734	3.92
		1%	3.657	5.256
		Finite Sample: n=35		
		10%	2.331	3.417
		5%	2.804	4.013
		1%	3.9	5.419

### NARDL ShortRun ECM

ARDL Error Correction Regression

Dependent Variable: D(AGDP)

Selected Model: ARDL(2, 3, 4, 4, 0, 3)

Case 2: Restricted Constant and No Trend

Date: 06/12/23 Time: 23:33

Sample: 1981 2021

Included observations: 36

ECM Regression				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
$d(AGDP(-1))$	0.506451	0.087373	5.796400	0.0000
$d(POPG\_POS)$	-115.8838	18.07491	-6.411308	0.0000
$d(POPG\_POS(-1))$	79.52912	13.65879	5.822560	0.0000
$d(POPG\_POS(-2))$	28.38271	7.535387	3.766589	0.0021
$d(POPG\_NEG)$	76.85737	13.31264	5.773261	0.0000
$d(POPG\_NEG(-1))$	45.56472	14.81785	3.074988	0.0082
$d(POPG\_NEG(-2))$	-10.28262	11.52250	-0.892395	0.3873
$d(POPG\_NEG(-3))$	44.47844	8.920784	4.985935	0.0002
$d(LFP)$	0.299307	0.358758	0.834288	0.4181
$d(LFP(-1))$	-0.280916	0.434268	-0.646871	0.5282
$d(LFP(-2))$	-0.856383	0.506494	-1.690806	0.1130
$d(LFP(-3))$	-0.905706	0.428630	-2.113027	0.0530
$d(GE)$	0.306104	0.114755	2.667454	0.0184
$d(GE(-1))$	-0.598477	0.136489	-4.384797	0.0006
$d(GE(-2))$	-0.685790	0.109446	-6.266003	0.0000
CoIntEq(-1)*	-1.091096	0.099555	-10.95970	0.0000
R-squared	0.900345	Mean dependent var		0.142484
Adjusted R-squared	0.825604	S.D. dependent var		2.946575
S.E. of regression	1.230511	Akaike info criterion		3.553838
Sum squared resid	30.28312	Schwarz criterion		4.257624
Log likelihood	-47.96908	Hannan-Quinn criter.		3.799478
Durbin-Watson stat	3.121653			

\* p-value incompatible with t-Bounds distribution.

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	12.01150	10%	2.08	3
K	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	3.06	4.15

### NARDL ShortRun ECM

ARDL Error Correction Regression

Dependent Variable:  $d(AGDP)$

Selected Model: ARDL(2, 3, 4, 4, 0, 3)

Case 2: Restricted Constant and No Trend

Date: 06/12/23 Time: 23:33

Sample: 1981 2021

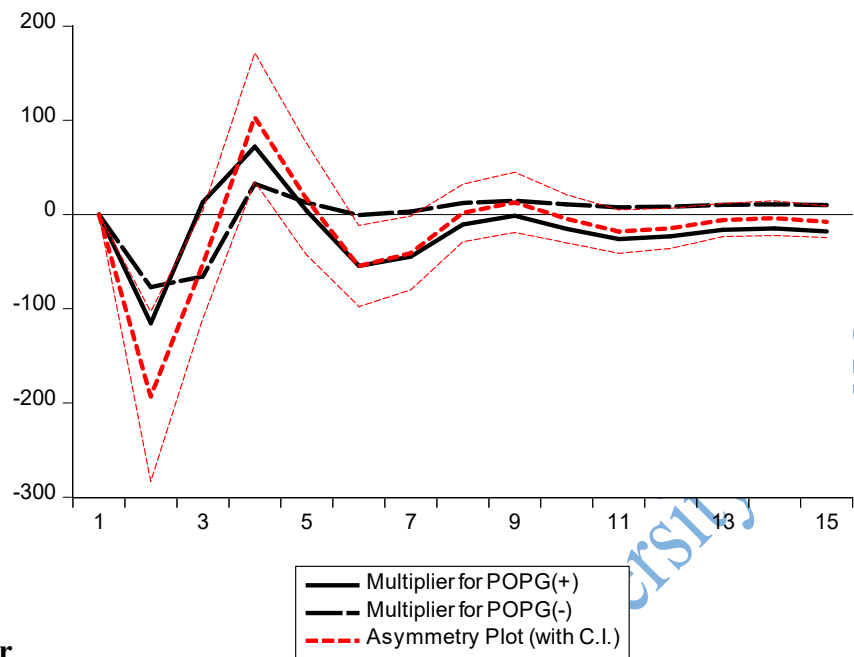
Included observations: 36

ECM Regression				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
$d(AGDP(-1))$	0.506451	0.087373	5.796400	0.0000
$d(POPG\_POS)$	-115.8838	18.07491	-6.411308	0.0000
$d(POPG\_POS(-1))$	79.52912	13.65879	5.822560	0.0000
$d(POPG\_POS(-2))$	28.38271	7.535387	3.766589	0.0021
$d(POPG\_NEG)$	76.85737	13.31264	5.773261	0.0000
$d(POPG\_NEG(-1))$	45.56472	14.81785	3.074988	0.0082
$d(POPG\_NEG(-2))$	-10.28262	11.52250	-0.892395	0.3873
$d(POPG\_NEG(-3))$	44.47844	8.920784	4.985935	0.0002
$d(LFP)$	0.299307	0.358758	0.834288	0.4181
$d(LFP(-1))$	-0.280916	0.434268	-0.646871	0.5282
$d(LFP(-2))$	-0.856383	0.506494	-1.690806	0.1130
$d(LFP(-3))$	-0.905706	0.428630	-2.113027	0.0530
$d(GE)$	0.306104	0.114755	2.667454	0.0184
$d(GE(-1))$	-0.598477	0.136489	-4.384797	0.0006
$d(GE(-2))$	-0.685790	0.109446	-6.266003	0.0000
CoIntEq(-1)*	-1.091096	0.099555	-10.95970	0.0000
R-squared	0.900345	Mean dependent var		0.142484
Adjusted R-squared	0.825604	S.D. dependent var		2.946575
S.E. of regression	1.230511	Akaike info criterion		3.553838
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Log likelihood	-47.96908	Hannan-Quinn criter.		3.799478
Durbin-Watson stat	3.121653			

\* p-value incompatible with t-Bounds distribution.

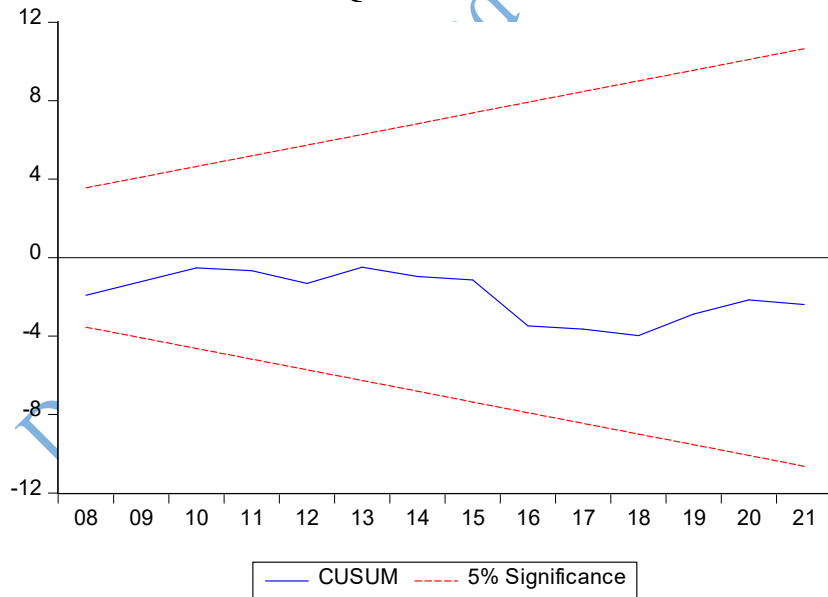
F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	12.01150	10%	2.08	3
K	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	3.06	4.15

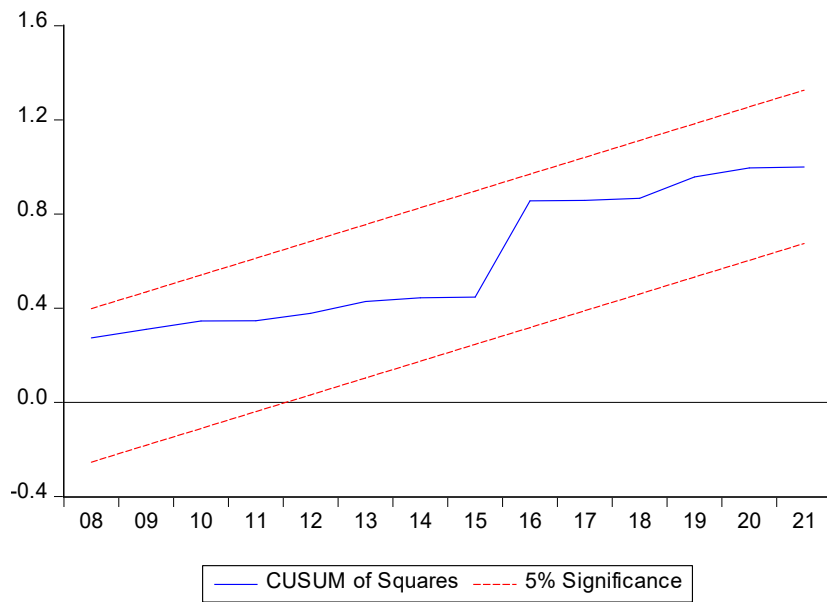
**Dynamic**



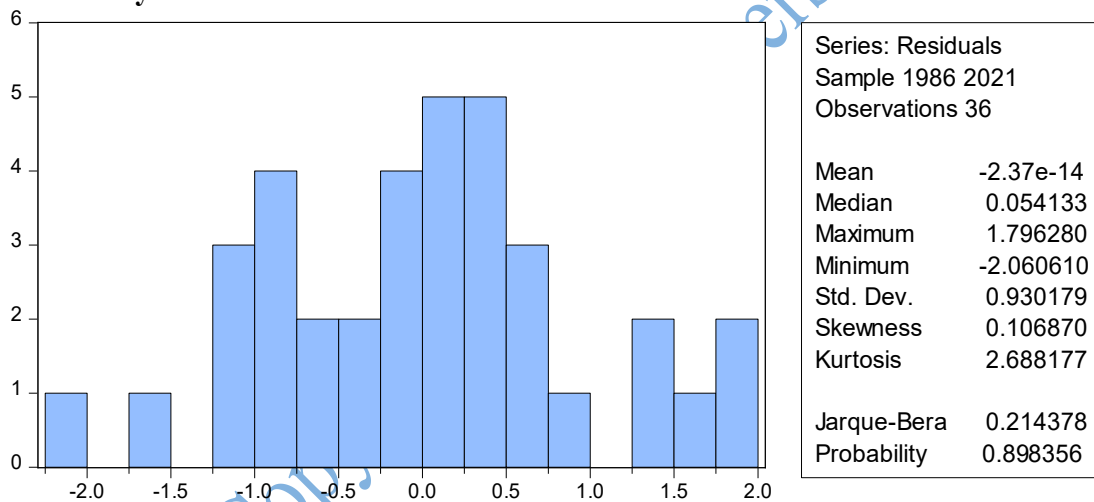
**Multiplier**

**CUSUM and CUSUM SQUARE**





### Normality Test



### Heteroskedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.779176	Prob. F(21,14)	0.1352
Obs*R-squared	26.18743	Prob. Chi-Square(21)	0.1994
Scaled explained SS	3.342966	Prob. Chi-Square(21)	1.0000

### AutoCorrelation Test

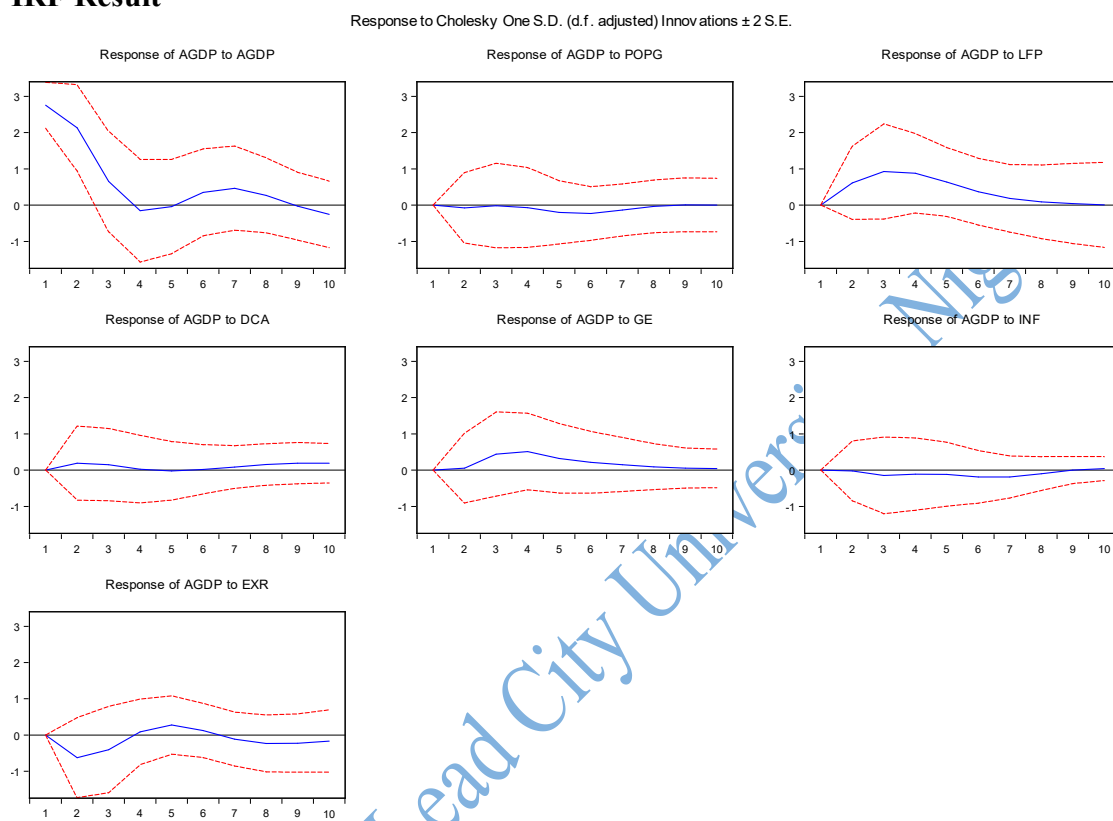
Breusch-Godfrey Serial Correlation LM Test:

F-statistic	5.758120	Prob. F(4,10)	0.0624
Obs*R-squared	25.10164	Prob. Chi-Square(4)	0.0000

## Appendix IV

### Objective Three: Result of the Assessment of the Response of Food Production to Shocks in Population Growth in Nigeria

#### IRF Result



#### Variance Decomposition Result

Period	S.E.	AGDP	POPG	LFP	DCA	GE	INF	EXR
1	2.755387	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	3.599077	93.71034	0.043727	2.908378	0.291084	0.021668	0.003350	3.021449
3	3.826492	85.82263	0.040039	8.421079	0.415547	1.361658	0.150839	3.788210
4	3.965890	80.04763	0.066146	12.75399	0.390853	2.951290	0.218291	3.571807
5	4.045734	76.92877	0.309008	14.72347	0.377992	3.477035	0.291512	3.892210
6	4.096107	75.78785	0.623678	15.16778	0.371421	3.662262	0.498918	3.888099
7	4.138755	75.50915	0.718035	15.05755	0.406333	3.723374	0.700229	3.885324
8	4.160175	75.14975	0.717798	14.95040	0.539395	3.735099	0.746720	4.160835
9	4.171444	74.74952	0.714201	14.88038	0.748157	3.731337	0.742721	4.433682
10	4.187148	74.55611	0.708876	14.76917	0.946317	3.715374	0.746638	4.557511

Cholesky Ordering: AGDP POPG LFP DCA GE INF EXR

## **Bio Data**

### **A. Personal Data:**

Name:

Email address:

Phone number:

House address:

Date of birth:

Place of birth:

Nationality:

Marital Status:

Name and address of next of kin:

### **B. Educational Background**

#### **Educational Institution Attended With Dates**

- i. Primary Education:
- ii. Secondary Education:
- iii. Higher Educational Institution:

### **C. Working Experience With Dates**

### **D. Awards and Fellowships (if any)**

### **E. Membership of Academic Professional Bodies**

### **F. Publications (if any)**

- 1 Thesis/Dissertations
- 2 Books
- 3 Scholarly Articles
- 4 Notable Scholarly or Professional Accomplishments
- 5 Major Conferences/ Workshop Attended

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**Signature**

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**Date**

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### **The University Compliance Certification**

This is to certify that this thesis written by Ifetolase Dorcas, OJENIYI with Matriculation Number LCU/PG/001478 in the Department of Economics, Faculty of Management and Social Sciences, Lead City University, Ibadan is in full compliance with the approved University format and style.

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**Signature**

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**Date**

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