AGRICULTURAL TRADE INTENSITY AND FOOD SECURITY IN NIGERIA

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DECLARATION

I declare that the work in this dissertationentitled "Agricultural Trade Intensity and Food Security in Nigeria" has been carried out by me in the Department of Economics, Ahmadu Bello University, Zaria.The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other institution.

_____	_____	_____
Name of Student	Signature	Date

CERTIFICATION

This dissertation entitled "AGRICULTURAL TRADE INTENSITY AND FOOD SECURITY IN NIGERIA: 1981 - 2015" by Muhammad Mustapha YAKUBU meets the regulations governing the award of the degree of M.Sc. Economics of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This dissertation is dedicated to the Almighty Allah, my parents: Mr and Mrs. Yakubu Ozigi (both of blessed memory); Prof. M. S. Audu and my major supervisor, Dr Mohammed I. Shuaibu, for their varied but inestimable value added to my life.

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ABSTRACT

The divergence between agricultural trade intensity (ATI) and food security in Nigeria suggests that the linkage is ambiguous. Illustratively, the degree of openness in the agriculture sector increased from 9% in 1981-1985 period to 12% in 2011-2015 while a 25% reduction in per capita daily dietary energy supply was observed during the same period. This crucial nexus in Nigeria has received very little empirical attention with existing studies being limited in terms of scope of food security and methodology employed. Therefore, this studyexamined the impact of ATI on the three dimensions of food security (availability, access and utilization)using separate models that were estimated using annual time series data for the period 1981 to 2015. Sequel to establishing that the data were a mixture of I(0) and I(1), the Autoregressive Distributed Lagged bound testing approach to cointegration was used to investigate the existence and nature of the long-run and short-run relationships. The error correction model-causality framework was employed to further investigate the extent and direction of causation between ATI and food security. The study finds that ATI has a negative and significantimpact on the three dimensions of food security in the long run;suggesting a worsening of the food insecurity situation in Nigeria over the long term. However, the positive impact of ATIon food security in the short run is not sustainable as it is offset by the negative and significant impact in the long term but provides impetus for making contemporaneous adjustments. The study concludesthat Nigeria has unduly relied on agricultural trade and failed to appreciate the multi-dimensional and general-equilibrium nature of food security, thereby leaving the country food insecure.Accordingly,the study recommends an overhaul of the entire Sustainable Food System (SFS)in terms ofsustainable food production, processing and storage; infrastructure, institutions and processes in a bid to enhance food security in Nigeria.

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ACRONYMS

ACR: Agricultural Credit

ADF: Augmented Dickey-Fuller

ADOP: Agricultural Degree of Openness

AL: Agricultural Land (Irrigated)

ARDL: Autoregressive Distributed Lag

ATL: Agricultural Trade Liberalization

CBN: Central Bank of Nigeria

COMTRADE: Commodity Trade website

CPI: Consumer Price Index

SFS: Sustainable Food System

ECM: Error Correction Model

ECT: Error Correction Term

EDF: Educational Fund

EXCH: Exchange Rate

FAC: Food Access

FAO: Food and Agriculture Organization

FAOSTAT:FAO Statistical database

FAV: Food Availability

FMARD: Federal Ministry of Agriculture and Rural Development

FMF: Federal Ministry of Finance

FS: Food Security

FUT: Food Utilization

HLTH: Health Funding

NBS: National Bureau of Statistics

PP: Phillips-Perron

RGDP: Real Gross Domestic Product

RNF: Rainfall

SOFI:the State of Food Insecurity (in the World)

WDI: World Development Indicators

WITS: World Integrated Solution

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Background to the Study

Food security (FS) is achieved when people have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and preferences for an active and healthy life (Food and Agriculture Organization - FAO, 2001). The availability, access and utilization of food emerged from this definition as dimensions of FS, reflecting the importance of changing socio-economic and structural challenges such asvolatile food prices, scarcity of inputs, climate change, and demographic dynamics especially in developing countries. Agricultural trade intensity on the other hand is a variable used to denote the degree of openness of an economy to agriculture trade. It is viewed as the extent to which the agricultural sector contributes to external trade (Ng and Yeats, 2003). It is often regarded as a measure of trade liberalization in the agricultural sector.

In a bid to provide sustainable food security for its estimated population of about 178.5 million (World Development Indicators -WDI, 2015), Nigeria's agricultural trade has increasingly been liberalized since 1980s in linewith the rise of liberal economic policies on a global scale (World Trade Organization - WTO, 2012). Consequently, agricultural subsidies declined from an average of 45% in 1989/1991 to an average of 24% in 2013/2014, while tariffs have also reduced from average of 35% in 1988/89 to 15% in 2013/2014 (National Bureau of Statistics - NBS, 2014). Evidence shows that some of Nigeria's food security metrics improved within the same period. According to a report by FAO in 2015, Nigeria recorded 11.2 million undernourished people in 2012-14, down from 20.9 million in 1990-92 (i.e., a 46.4% reduction) and 6.4% prevalence of undernourishment in 2012-2014, down from 21.3% in 1990-92 (i.e., a 69.7% decrease). Notably, the reliability of these seeming improvements is offset by Nigeria's low living standard and inefficient distributive mechanism as indicated by the high poverty rate of 62% and an average Gini inequality index of 56%.

The debate on the effects of agricultural trade liberalization on food security is still ongoing. The proponents of open trademaintain that it raises availability of food through efficient allocation of resources and facilitates the flow of products fromsurplus to deficit areas.They opine that open trade raises incomes of exporters (in the form of higher prices than would be received in autarky) and real incomes of consumers (through lower prices than would otherwise be paid), thereby increasing food access (Thomas and Morrison, 2006; World Bank, 2012 and Lamy, 2013). The opposing view is that free trade is inimical to food security as it stifles the livelihood of smallholding farmers and encourages export of food from deficit regions and therefore recommends protectionist trade regimes (Madeley, 2000). Another strand of the debate navigates between the first two, making a case for liberalized trade complemented with appropriate domestic policies (See De Schutter, 2011; Burnett and Murphy, 2014; and Clapp, 2014).

In response to the dictates of prevailing economic conditions in different periods, Nigeria has witnessed a number of trade policy episodes. Specifically, trade policy in Nigeria has moved between free and protectionist regimes based on the thrust of government policy. The second half of the 1980s witnessed a significant shift in trade policy direction towards increased liberalization. This change may be attributed to growing pressure to liberalize agricultural trade consequent upon the adoption of Structural Adjustment Programme (SAP) in 1986. The policy required drastic reductionof or complete removal of "market-distorting" agricultural domestic supports such as subsidies and price control/stabilization measures such as embargoes considered as inhibitive to free flow of commodities across national boundaries (Oyejide, Ogunkola and Alaba, 2006).

In the quest for sustainable food security, the Nigerian government instituted various development projects such as Farm Settlement Scheme in 1959, the National Accelerated Food Production Project (NAFPP, 1972), the Agricultural Development Projects (ADP, 1975) and Operation Feed the Nation (1976). Others include the River-BasinDevelopment Authority (RBDA, 1976), Green Revolution (1980), Directorate for Food, Road and Rural Infrastructure

(DFRRI, 1986). A major objective of these programmes was to improve the nutritional value of food intake. Within the period 1989-1992, about 172, 000 kilometres of feeder roads were constructed, thereby improving farmers' access to markets and consumers' food access. About 11, 400 tons of arable crops and 8.8 million of fishes were also added to the food basket of the nation during the same period.

The positive trend highlighted above was largely offset by suboptimal capacity utilization in the sector as well as poor policy co-ordination. The programmes were also characterized by low monitoring and evaluation due to paucity of requisite capacity and logistic support, and the perennial problem of misappropriation of fund.

The Agricultural Transformation Agenda (ATA) is Nigeria's most recent agriculture development policy and its primary objective is sustained development of agricultural value chain and increased access for rural farmers to credit and requisite technology.This policy led to the creation of the Growth Enhancement Scheme (GES) that utilized mobile device services known as e-wallet to distribute fertilizer to farmers, thereby saving about ₦25billion (ATA Report, 2013). Also, equipment for the production of cassava bread attracted zero duty while 40% substitution of wheat for cassava was attained from 20% tax rebate for bakeries. Consequently, about 8million metric tons (MT) of food was added to domestic food supply in 2012 just as wheat imports decreased from about 4.1 million MT in 2010 to 3.7 million MT in 2012 (NBS, 2013). As at November 2014, Nigeria's food reservoir rose from less than one million metric tons (1mmtns) to over 20 mmtns (NBS, 2015).

Notably, towards the end of ATA's lifespan, the economy began to slow down due to over reliance on oil proceeds as crude oil price began to slide. This dampened the achievement of the ATA. The situation has since worsened as crude oil price hovered around US40 dollars per barrel, with one United States dollar being exchanged for about ₦400 as at August, 2016 in the parallel market as against the floated official rate of about ₦ 300/US dollar. This represents a gap of about 33% down from about 52% in March 2016. That is, the policy of floating the exchange rate determination of the naira recently adopted has only narrowed the gap between

the official and the parallel market rates. Both rates have increased, translating into a stagflation. The ripple effect of these developments on food security is indicated in the increasing food prices.

Amidst trade policy incoherence indicated in the customs service's opening the borders for more rice import versus the Central Bank of Nigeria's (CBN) forex ban on some products including rice and tomato/tomato paste, a new agriculture policy framework was launched in July, 2016. The current agricultural policy framework named the Agriculture Promotion Policy (APP) otherwise referred to as the Green Alternative is a medium term framework for the period 2016 to 2020. It seeks to tackle food security challenges as it declares food as a human right; targeting 6% - 12% growth rate of agricultural GDP in order to double agricultural household incomes in 6 – 12 years. It also seeks to broaden the agriculture value chain, prioritize food crops, boost market competitiveness, enhance value added and promote inter-sectoral linkages.The strategic implementation of the framework is expected to improve food security in Nigeria. However, its purposeful implementation is yet to be vigorously pursued as at the third quarter of 2016.

1.2 Problem Statement

Nigeria has since the 1980s embarked on agricultural trade liberalization (ATL) particularly followingthe adoption of SAP. The range of food import tariff rates has reduced from an average of 50% to 20% in the 1985/86 period to 35% to 5% in 2013 (WTO, 2013). Observably, despite the improvements in food security according to the FAO's SOFI (2015), Nigeria is still classified as lower middle income and net food importing country (WDI, 2013).This is an indication that Nigeria's food security in terms of availability, access and utilization still remains at some low and precarious levels.

Nigeria is heavily dependent on food imports, thereby worsening terms of agriculture trade. In terms of output, agriculture's contribution to Gross Domestic Product (GDP) has continued to fall or at most fluctuate over the recent past. According to data obtained from Central Bank of

Nigeria's (CBN) statistical bulletin (various issues), the agriculture sector's contribution to GDP fell from over 60% in the pre-oil boom era (i.e., before 1970s) to an average of 36% in the 1970s before it marginally rose to 41% in the 2009-2014 period; **r**eversing the country's status from food self-sufficiency to import-dependency**.** This increased the country's vulnerability to global food price shocks such as that of 2007-2008 during which Nigeria witnessed 25% decline in food production (CBN, 2010) and the consequent all-time high food price index of 160 (NBS, 2011).Over 60% of Nigeria's domestic consumption of the major staple grains – rice, wheat, soyabeans, millet, etc. – has consistently been from imports over the last two decades(NBS, 2015).

Theseworrisome developments in addition to the divergence between openness and food security motivates an empirical probe of the nexus. Illustratively, as degree of openness in agricultural sector that averaged about 10% in 1981/85 period increased to an average of about 13% in 2011/15 (computed from COMTRADE data), Nigeria's food security metrics have been falling as evidenced by a 25% reduction (FAOSTAT, 2015) in per capita daily dietary energy supply within the same period. This is in addition to the high percentage of under-five children affected by anemia in Nigeria which averaged 75.07% for the period of 1981 to 2015 with too high a minimum of 71% (see table 2.2 in the appendix). This is a clear indication that under-nutrition has been at intolerable levels for some decades now. These developments reinforce the worries earlier expressed by researchers. Clapp (2014) notes that though open trade can increase food availability through efficient use of resources and improves access for those who record increases in income, but not (immediately) of those who were formerly protected. More so, according to De Schutter (2011), open trade can improve the diversity of diets and with it utilization, but may introduce some new threats to nutrition. Worse still, it reduces the risks associated with poor domestic harvests, but makes international instability a relevant issue.

According to the WTO Trade Policy Review (2011) for Nigeria, commitment to some multilateral and sub-regional trade agreements such as the Uruguay Round Agreement on

Agriculture (AoA) and the ECOWAS Common External Tariff (CET) has led to significant liberalization of the country's food and agricultural trade. Recent evidence shows that the liberalization of agricultural trade has increased Nigeria's reliance on agricultural imports, as reflected in the high food import bills such as₦1.18 trillion spent within the 17 months between January 2014 and May 2015 on food imports (CBN, 2015). This is against the country's vast agricultural endowments ofover 80% of its land being cultivable and 230 billion cubic meters of water available for fishing and aquaculture(FAO, 2014). It is against this background that certain questions arise.

1.3 Research Questions

The study seeks to provide answers to the following research questions:

(i) What is the impact of agricultural trade intensity on food availability in Nigeria?

(ii) How does agricultural trade openness affect food access in Nigeria?

(iii) To what extent has agricultural trade flow contributed to food utilization in Nigeria?

1.4 Research Objectives

The general objective of the study is to evaluate the impact of agricultural trade intensity on food security in Nigeria. To achieve this, the study seeks to:

(i) assess the impact of agricultural trade intensity on food availability in Nigeria;

(ii) investigate the effect of agricultural trade openness on food access in Nigeria; and

(iii) ascertain the contribution of agricultural trade flows to food utilization in Nigeria.

1.5 Research Hypotheses

To answer the research questions, the following hypotheses are tested.

(i) H^1_0: Agricultural trade intensity does not significantly affect food availability in Nigeria.

(ii) H^2_0: Agricultural trade openness has not significantly influenced food access in Nigeria.

(iii) H^3_0: Agricultural trade flow does not significantly contribute to food utilization in Nigeria.

1.6 Justification of the Study

The debate about the contribution of open trade in agriculture to food security is yet to reach a consensus. Nigeria's agricultural trade is increasingly being liberalized as a means of achieving sustainable food security in line with regional and multilateral trade agreements. However, ample evidence shows that Nigeria still remains a net food importing and largely food insecure country (WDI, 2013; SOFI, 2015). The open trade argument of efficiency gains stemming from comparative advantage (Lamy, 2013) does not pay explicit attention to the issue of food security and also assumes perfect competition in a world characterized by market imperfections (Schumacher, 2013). This results to a limited understanding of food security. This study therefore considers a multi-dimensional model of food security with a view to understanding the effect of openness on its availability, access and utilization in Nigeria.

The theoretical literature shows the channels through which the degree of trade openness is transmitted to food security (cf. USAID, 2006 and Diaz-Bonilla and Ron, 2010). A crucial channel is trade-growth linkage whose proposition that increased food availability and access should result from the commitment of revenues from trade taxes is hindered by possible diversion of such revenues in the face of competing needs. The price transmission channel also has implications for household consumption and income. This has implications for food security in Nigeria and this is partly explained by the low living standard as indicated by the high poverty rate of 62% and Gini inequality index of 56%.

The methodological literature has focused on the use of computable general equilibrium (CGE) models that are limited by high level of aggregation (McCorriston, 2013). Some others have employed descriptive methods that do not sufficiently analyze the underlying data generating process as well as inherent dynamic relationships. For example, Chandran (2010) analyzed trade intensities between India and some Association of South East Asian Nations (ASEAN)

countries using descriptive method that failed to account for important variables such as exchange rates, price volatility and climate conditions and even ignored the issue of food security. This study seeks to address these gaps by employing a dynamic modelling approach to assess the short and long run relationships between food security and its potential determinants. Specifically, cointegration and error correction model (ECM)-causality approach are relied upon. Furthermore, the ECM-causality framework measures the speed of adjustment of the short-run processes to the long run processes, thereby providing insight into the causal link between the variables.

Specifically, the bounds testing approach to cointegration proposed by Pesaran, Shin and Smith (2001) would be employed to test for cointegration. This is because it can be applied if the regressors are a mixture of I(0) and I(1). Moreover, ascertaining the order of integration of the underlying regressors prior to testing the existence of a level relationship between the variables is not required (Pesaran et al., 2001: 315). Also, the procedure is applicable even when the explanatory variables are endogenous (Alam and Quazi, 2003, p.93) and also robust even for small sample sizes (Tang and Nair, 2002).

There is paucity of empirical research on this important nexus in Nigeria. A related study in Nigeria, Oyejide, Ogunkola and Alaba (2006), concentrated only on food availability instead of the broader food security measures. They also relied on descriptive method thereby ignoring the dynamics of the relationship. Similarly, Abdullateef and Ijaiya (2010) did not consider the stability component as well as other non-trade variables that may influence food security in Nigeria. This study seeks to fill these gaps and its findings will serve as important inputs in the formulation and implementation of food security policies in Nigeria. This is particularly important as food security remains a key component of the national and global development agenda - the Sustainable Development Goals (SDGs)[1].

[1]The SDG no. 2 seeks to "end hunger, achieve food securityand improved nutrition and promote sustainable agriculture"

1.7 Scope and Limitations of the Study

The study focuses on the effects of changes in food imports and exports on variousdimensions of food security, namely availability, access and utilization. Datasetsobtained from various secondary sources spanning the period 1981 to 2015 were utilized. This period is chosen to facilitate comparison of the nexus among various agricultural trade policy regimes. This period also covers the oil boom era associated with increasing neglect of agricultural sector as well as the period of intense trade liberalization associated with the adoption of SAP in 1986. The global food crisis of 2007-2008, during which food prices increased by 55% from June 2007 to February 2008 in Nigeria (NBS, 2009), also falls within the period considered. The period also covers the current economic challenges that stemmed from dwindling oil prices coinciding with eroding value of the naira as reflected in the high exchange rate. This has affected food access as food prices continue to increase. We acknowledge that the nexus between ATI and FS would have been better captured using high frequency data, given the probable instantaneous reaction of FS to trade policy changes. However, we restricted our analysis to the use of annual series due to data constraint.

1.8 Organization of the Study

The study is structured in five chapters. Chapter one provides a general introduction to the study as it comprises the background to the study, problem statement, research questions and objectives, justification for the research and scope of the study. Chapter two reviews the relevant literature in terms of the conceptual, theoretical as well as empirical issues related to the nexus. Methodology is presented in chapter three, while chapter four concentrates on presentation and discussion of the results. The summary, conclusion and recommendations form the thrust of chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews related literature. The next section reviews relevant concepts followed by a review of theoretical literature on the relationship between agricultural trade intensity and food security. The methodological approaches and empirical results of related studies are reviewed in the subsequent section.

2.2 Conceptual Issues

2.2.1 Agricultural Trade Intensity

Trade intensity is the extent to which the value of trade between two or more countries falls above or below expectations on the basis of their importance in world trade (Kunimoto, 1977). It is the share of a country's (or some countries') exports going to some partner(s) divided by the share of world exports going to the partner(s)(Ng and Yeats, 2003).Trade intensity index (TII) between exporter(s) $i$and importer(s) $j$is thus given by: (x_{ij}/x_i) / (x_{wj}/x_w),where $x_{ij}$and$x_{wj}$are the values of country i's exports and of world exports to country(ies) j and where $x_i$and $x_w$are$i$'s total exports and total world exports respectively.An index of more (less) than one indicates larger (less) exports from $i$to $j$than would be expected, given$j$'s importance in world trade.

This study focuses on exports and imports of agricultural outputs in Nigeria, particularly food items as classified under Standard International Trade Classification (SITC).The study therefore utilizes a modified form of the degree of openness proposed by Sachs and Warner (1995) by focusing on the sum of agricultural exports and imports divided by agriculture's share of GDP. This choice is driven by the need to consider aggregate agricultural trade flows to and from the rest of the world.

2.2.2 Food Security

Definition of Food Security

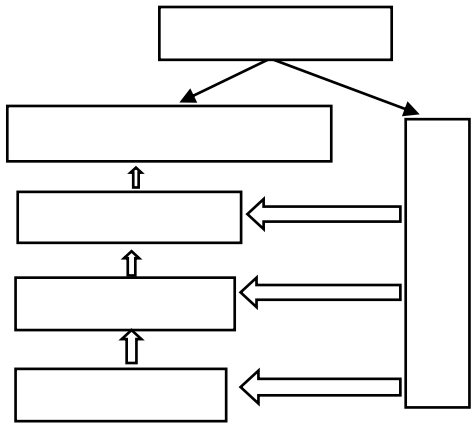
Food security has been defined in many ways (Clay, 2002). The initial focus was on the volume and stability of food supplies. Thus, food security was defined in the 1974 FAO's World Food Summit (WFS) as:"availability of adequate world food supplies (of basic foodstuffs) at all times to sustain steady food consumption and to offset fluctuations in production and prices." In 1983, the concept was expanded to include securing access by vulnerable groups to food supplies, implying that attention should be paid to both the demand and supply sides of food security by ensuring that all people have both physical and economic access to basic food requirements.

World Bank (1986) drew a distinction between *chronic food insecurity,* associated with problems of unfavourable climate and interminable structural poverty; and *transitory food insecurity,* linked to sporadic periods of intense pressure caused by natural disasters, economic slowdown or conflict. This brings out the temporal dynamics of food security, arriving at: "access of people *at all times* to enough food for an active, healthy life".The World Food Summit (WFS, 2001)thus arrived at: "Food security is achieved when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life."

Availability, access, utilization andstabilityemerged from the definition as the pillars of food security(FAO, 2001)(See Figure 1). Availability is achieved if adequate food is at people's disposal. Food availability is a basic but not sufficient condition for food security because food may physically exist but remain inaccessible for those in need.Access is when consumers have sufficient and sustainable resources to obtain nutritious food.Utilization refers to the ability of the human body to ingest and metabolize food;with emphasis on food quality in terms of nutritional value(Usman, 2010). Thus, achieving food security implies that sufficient quantity of safe and nutritious foodis consistently within reach, individuals have adequate resources to

acquire food, they have sound knowledge of nutrition and child care that they put to good use, and have access to adequate health and sanitation services.

Figure 1: The Pillars of Food Security



Source: FAO (2001)

Measurements/Indicators of Food Security

Confirming FAO's (2006) submission that no single indicator is able to capture all the dimensions of food security, the review of food security literature shows that an array of indicators has been used in various studies. It is basically measured in terms of national food availability which equals the sum of domestic output, net food imports (imports - exports) and food aid (Clay, 2002; Barrett, 2010). It is also gauged by per capita food availability, that is, the ratio of total food availability to population size. This captures the quantity available to each person in the economy in kilocalories. The food balance has also been used to indicate the magnitude of food security (Fosu, Heerink and Iboudo, 1996). This is the algebraic difference between the quantity of the actual food supplied and the quantity of food needed. The food balance is in surplus (deficit) when the supply of actual food is greater (less) than the quantity of food needed by the people in question (ibid).

Agricultural price index is another handy indicator of global food availability: rising prices point to a supply deficit and excess of demand. This explains why world food security concerns re-emerged in 2008 following the agricultural price surge (Clapp, 2013). The Bonilla Index (BI) proposed by Diaz-Bonilla, Thomas, and Robinson (2003)suggest the ratio of total exports to food imports as a useful indicator of access to food by individual countries as it measures

national capacity to finance food imports from exports. This approach provides an interesting indicator to track the vulnerability of food security to trade in net food-importing countries. These values depend on world price trends and their expression in local currency *vis a vis* the exchange rate (Huchet and Laroche, 2014).

FAO (2003) categorized national level indicators of food security in terms of availability, access, utilization and stability. Various indicators that are relevant at this level include: per capita food production; daily caloric intake per capita and proportion of individuals undernourished as calculated by FAO; food commodity price stability; food import bill; and food self-sufficiency ratio. In line with FAO's methodology, Baffes and Dennies (2013) utilized supply of food commodities in kilocalories per person per year (for food availability); depth of the food deficit (for food access); infant mortality (for food utilization) and per capita food supply variability (for stability).

2.3 Theoretical Review

2.3.1 International Trade Theories

International trade theory can be traced to mercantilism whose basic postulation is that a country can only be rich if it exports more than it imports, especially through acquisition of precious metals such as gold. Some of the main proponents of this theory were Jean Baptiste Colbert, Thomas Hobbes and Thomas Mun (De Schutter, 2011). Mun (1630) observed that: "…to increase our wealth…sell more to strangers yearly than we consume of theirs in value". Mercantilism is faulted on the basis that a country's exports cannot outweigh its imports in all commodities (Gonzalez, 2011) and that it fails to envisage the reactions of trading partners (Fletcher, 2010).

Adam Smith addressed these issues in his theory of absolute advantage, assuming a two-by-two-by-two model, that is, two countries trading two commodities that rely on two factors of production; labour and capital. The theory postulates that a country should specialize in the production and export of products it can produce more efficiently (that is, more output per unit of input) than others, while importing those goods where it is less productive than other

countries (Dunn and Mutti, 2004).This implies that a nation need not gain at the expense of others, since all nations can benefit simultaneously (Carbaugh, 2004; Sylvester and Aiyelabola, 2012). However, the question of whether or not trade should still take place when one partner can produce both commodities more efficiently than the other partner (i.e., has absolute advantage in both goods) arise. The theory fails to answer this question satisfactorily, thereby giving rise to Ricardo's theory of comparative advantage.

David Ricardo posited that even if a nation has an absolute disadvantage in the production of both goods, there exists a basis for mutually beneficial trade. The less efficient nation should specialize in the production and export of the good in which it is relatively less inefficient (where its absolute disadvantage is least) while the more efficient nation should specialize in the production and export of the good in which it is relatively more efficient (where its absolute advantage is greatest). With this, more goods are produced and the wealth of both countries increases as comparative advantage depends on relative costs and arises from better price abroad than at home(Mankiw, 2007).The theory assumes the following: only 2 countries and 2 goods; no transportation costs; no price differences for resources in both countries; Resources can move freely from producing one product to producing another product; constant returns to scale; fixed stock of resources. Notably, relaxing and modifying some of these assumptions is common tosubsequent trade theories.

In this regard, Heckscher (1919) and Ohlin (1933) postulated that comparative advantage arises from differences in factor endowments, as opposed to Ricardo's theory that stresses productivity. The theory relies on a two-by-two-by-two model. The fundamental distinction between the Ricardian and H-O models[2] is that while the former assumes that production technology differs between countries, the latter assumes that they are the same. The assumption

[2]The model is sometimes referred to as the Heckscher-Ohlin-Samuelson (HOS) model or Heckscher-Ohlin-Vanek (HOV) model due to Samuelson's (1938) and Vanek's (1946) noteworthy extensions to the model. Here, all versions of the model will be simply referred to as the "Heckscher-Ohlin (H-O) model" or the more generic nomenclatures "Factor Proportions model" or "Factor Endowments model".

facilitates the understanding of how difference in resource endowments leads to trade and shows the impact that will arise due to these differences (Carbaugh, 2004).

The major thesis ofthe H-O model is that a capital-endowed country will export capital-intensive good, while the labour-abundant country will export labour-intensive good. The H-O theorem demonstrates that once trade is allowed between nations, products would be moved to the markets that temporarily have higher price. The theorem assumes perfect competition. That is, factors are paid based on their marginal productivity, which in turn depends on output prices. Thus, when prices differ between countries, so will their marginal productivities and hence, their returns. This means that price adjustments will make countries produce more export and less import, without necessarily specializing in the production of exports; unlike the Ricardian model.In this case, countries will experience efficiency both in production and consumption which in turn lead to a rise in welfare. However, this does not imply that everyone benefits. Some owners of factors of production will experience an increase in their real incomes and others a decrease. Trade will generate winners and losers (Charlse, 2007).

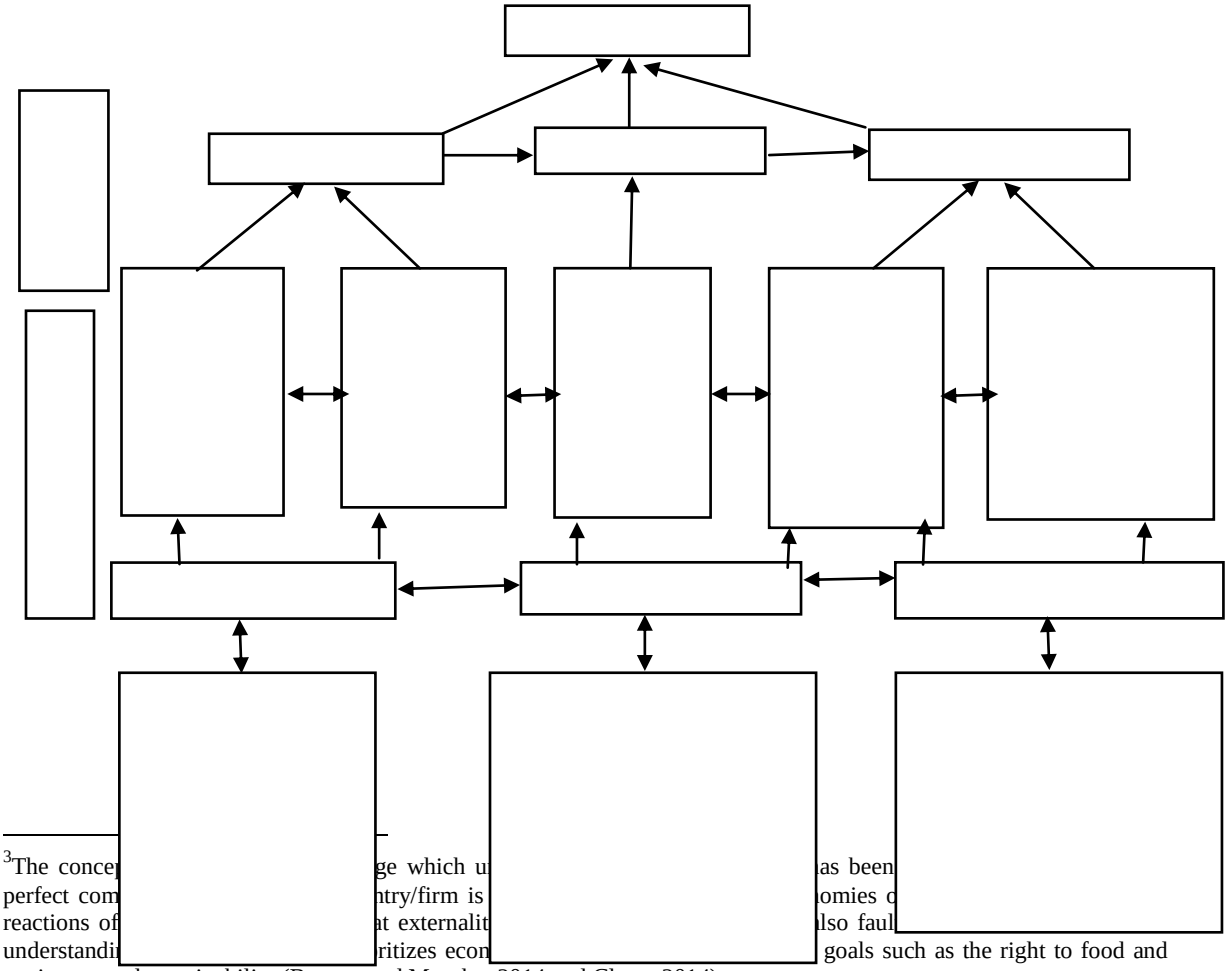
This model has been criticized based on its assumption that markets are competitive which is far-fetched in real world markets. Secondly, countries do not benefit equally from trade: because the relative gains depend on the terms of trade. Thirdly, the gap between the winners and the losers remains important especially in the absence of compensatory mechanisms within and between countries. Finally, the theory also assumes that all external costs are internalized, including environmental externalities, a subject of some contemporary debate. These limitations justify the position that countries may be better off intervening to restrict trade (Burnett and Murphy, 2014).

New trade theory (NTT)[3] (Krugman, 1979) relaxed the assumption of constant returns to scale (CRS) and assumed increasing returns to scale (IRS) which is associated with economies of scale. The theory supports the infant industry argument, pointing out that protectionist measures are a veritable means of increasing a nation's competitive advantage. With the aid of economies of scale, trade can increase the variety of goods, decreasing the average cost and hence reduces the prices of those goods. This amounts to increased welfare for both producers and consumers(Charles, 2007).

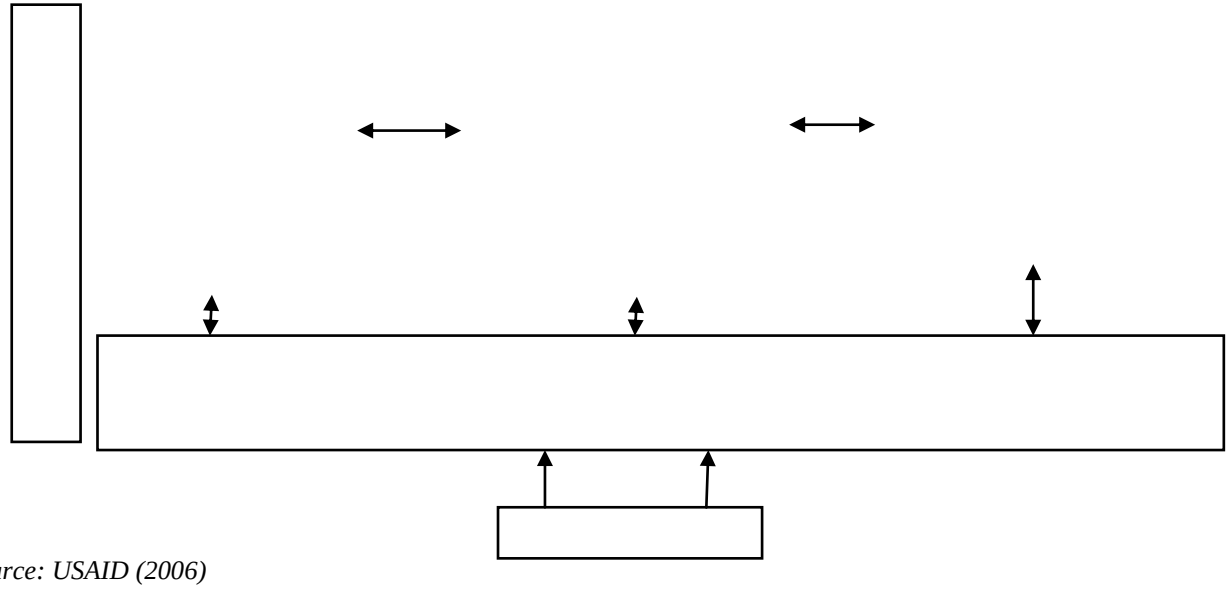
2.3.2 Food Security Models

Relevant models on food security and its relationship with trade are reviewed in this sub-section.Figure 2 depicts the linkages to desired outcomes of and potential risks to food security. This framework proposes that food availability derives from domestic agricultural output ideally through sustainable use of natural resources (water, land, vegetation).

Figure 2: Food Security/Insecurity Linkage



[3]The concep ge which u as been perfect com ntry/firm is omies o reactions of at externalit lso faul understandi ritizes econ goals such as the right to food and environmental sustainability (Burnett and Murphy, 2014 and Clapp, 2014).



Source: USAID (2006)

Domestic sources are enhanced by net food imports. Household purchasing power is key to access. Food utilization incorporates issues of food safety and quality, sufficiency of intake, and the metabolic efficiency of the body. The disruption of health infrastructure, lack of nutrition education and discriminations based on age/gender/race has detrimental impact on individual outcomes. Food security can be affected by changing terms of trade, market disruptions, employment insecurity, conflict, non-responsive safety net institutions. Observably, food security has both short term and long term implications a crucial determinant of which is trade (Laroche and Postolle, 2013) as illustrated in figure 3.

The Link between Trade and Food Security

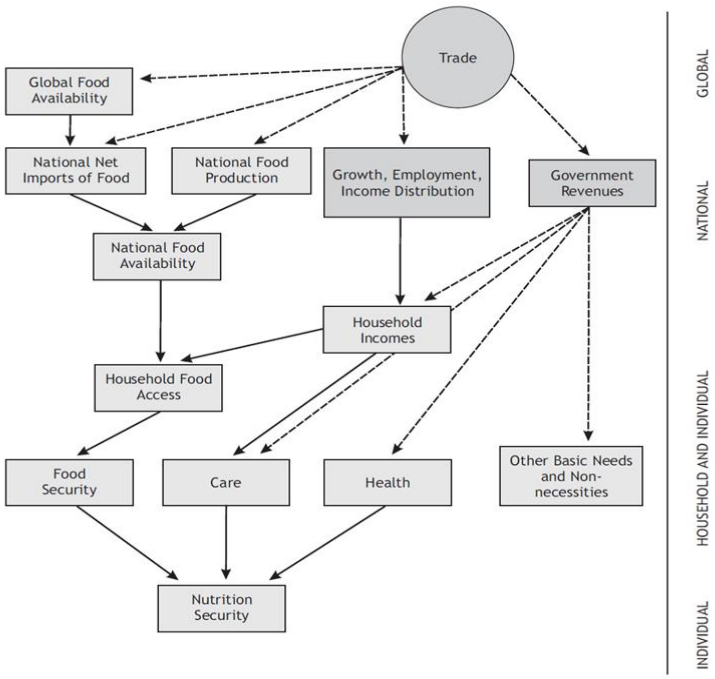
Figure 3 shows the different channels through which trade can influence food security which must be considered in any discussion on the nexus. The schema depicts the influence of trade on food availability through production andnet food imports; and food access through price adjustments;as well as utilization through deployment of trade tax proceeds on infrastructure such as education, water, sanitation and health facilities (Salvatici, 2014).

Specifically, trade affects both profits and householdexpenditures mainly through its effects on food prices. By influencing incentives for producers, trade also influences agriculture investment decisions such as adapting to new technologies. Trade also affects the cost of food, with important consequences for wages and the maintenance and accumulation of human capital, which also generate medium-term effects on welfare and production. Secondly, trade may also have an impact on the level and stability of economicgrowth, as

well as on employment generation, income distribution patterns, and poverty (Edwards, 1998; Dollar and Kraay, 2004; and Huchet, Le Mouël and Vijil, 2013).These variables determine income levels and variability, and thus determine whether or not economic growth supports the poor.

More so, government revenues, through tariff collection and through the impact of the rate and variability of growth on general tax collection, are also impacted by trade intensity.The level of revenues collected affects investment in technology, services, and infrastructure that support food and agricultural production; implementation of transfer policies(like food subsidies, conditional cash transfers, or other social safety net programs); and investments in health, education,and

Figure 3: The Link between Trade and Food Security



Source: Diaz-Bonilla and Ron (2010)

related areas (Diaz-Bonilla and Ron, 2010). Furthermore, external obligations related to trade and agricultural policies or to international financial institutions may also affect how government revenues are used. Finally, trade intensity may lead to lower or higher volatility in production, stocks, and prices at the world and/or national levels for different

commodities and markets. This influences the stability of food security status,through the income and spending channels (Thomas, 2006).

2.4Review of Empirical Literature

The foregoing suggests that whether trade improves food security or not remains inconclusive. The relationship between agricultural trade and food security has therefore received extensive empirical attention. While some studies posit that the effect of agricultural trade on food security is positive, others have presented negative and sometimes, mixed/inconclusive results.

Hertel et al. (1999) used a Global Trade Analysis Project (GTAP)model to investigate the effects of cuts in agricultural protection. They found that when agricultural protectionis cut globally by 40 percent, agricultural exports of developing countries as a whole would hardly change, but in East Asia, food imports would increase while in Latin America and Sub-Saharan Africa (SSA), exports would increase.Huang, Chen, and Rozelle (1999) used a partial equilibrium to assess the impact of tariffs and export subsidies on food consumption and grain self-sufficiency in China. They predicted that grain self-sufficiency would rise after an initial fall; and that grain market prices would decline under free trade, except for rice. They concluded that investment in research and development (R & D) for agricultural productivity was most effective policy to increase FS.

Using the findings from 14developing country case studies, FAO (2000) suggests that when considering whether any trade related growth can be attributed to the Uruguay Round, the evidence appears to be mixed. The study used a range of data series to compare for example, trends in the ratio of the food import bills to total agricultural export earnings. The study concludes that while trade liberalization led to an almost instantaneous surge in food imports, countries were often not able to increase exports due to significant supply-side constraints.

In a survey of impact assessments on the effects of liberalization from 39 countries, Madeley (2000) concluded that liberalization measures under SAP and the WTO's Agreement on Agriculture made the poor more vulnerable to food insecurity, adversely affecting small-scale farmers who faced competition from cheap imports, increased landlessness, higher farm input prices relative to the prices they received for their produce.Shapouri and Trueblood (2001) assessed the impact of removal of domestic support, rising food prices, and of full agricultural trade liberalization on food gaps. They found that the gaps were bridged albeit marginally in the study sample which included 67 low-income, food-deficit economies. Similarly, Meijl and van Tongeren (2001) also found out a marginal improvement in consumers' purchasing power for food products in response to reduction in tariffs in some Asian countries.

Another survey by Madeley and Solagral (2001) indicates that the evidence is mixed. While some of these studies find evidence to support the view that trade openness contributes to poverty reduction and accelerates the development process of a country, others observe that it has caused many farmers to leave farming and increased countries' imports dependency. Similarly, findings by Thomas and Morrison (2006) of 15 countries showed that the food security outcomes of liberalization varied by country and the food security indicator used. The empirical examination included quantitative and qualitative analysis of the impact of trade policy reforms on prices, production, and trade flows in the agricultural sector and on target variables, such as real incomes of farmers. Seven of the countries considered reportedly experienced an improvement in food security, while the outcomes for the rest were negative or ambiguous.

Beghin et al. (2003) used a dynamic CGE model to quantify the impact of trade and domestic agricultural distortions of high-income countries on terms of trade, trade flows and welfare of developing economies. They did this by modelling the removal of export subsidies, output and input subsidies affecting production decisions in high-income countries.Hertel et al. (2003) focused on the impact of trade liberalization on poor

households in Bangladesh, stratifying households according to their primary source of income into those that are specialized (95 percent or more of their income) in agriculture enterprises, non-agriculture enterprises, wage/salary labour, and transfers. Their findings suggested a mixture of improvement and deterioration in food security depending on several factors such as access to efficient transport facilities.

Oyejide, et al. (2006) reported an increase in calorie intake and a reduced number of the undernourished in Nigeria following reduction in import tariffs and changes in exchange rate. They, however, noted that although FS has improved, the impact of higher prices on production and investment has been limited. Chand and Praduman (2006) assessed the impact of a variety of trade-related policies such as exchange rate devaluation, fiscal deficit reduction, and reduced implicit bias against agriculture in protection on calorie intake in India. They reported that a rise in real prices of cereals resulted in decline in cereal consumption. Similarly, they found that undernourishment fell by 4% between 1992 and 2011, and per capita (p.c.) calorie intake rose by 5%. However, p.c. income of rural households rose with a decline in p.c. intake of cereals. Consumer prices rose, negatively impacting consumption. Hence, mixed findings.

Chowdhury, Farid and Roy (2006) employed a multi-market model of Bangladesh with upper and lower bounds of the estimates of the effect of multilateral trade liberalization (TL). They reported a rise in food grain consumption post-liberalization but per capita consumption of all cereals declined in the period 1992 to 2000 from 185 to 170 kg. The findings were mixed in that increase in food grain consumption was observed, but decrease in calorie intake predicted, particularly for urban poor and landless.Employing a range of descriptive analysis and multimarket CGE approaches to model the impact across countries, Ford and Rawlins (2007) revealed that policy reforms introduced in the 1980s and 1990s were associated with increased food insecurity and loss of rural livelihoods for several countries in the Caribbean. This was indicated by traditional export crops losing access to

markets, domestic food being crowded out by cheaper imports, adversely changing consumption patterns and worsening health problems.

Akanni et al. (2008) relied upon an OLS model to examine the effect of trade liberalization on agricultural exports in Nigeria. Aggregate domestic prices and other relevant parameters accounted for between 65% and 87% of the variability in income from Nigeria's agricultural commodity trade between 1990 and 1998. Chen and Duncan (2008) used a CGE model to assess the experience of China. They reported that accession to WTO was found to worsen food insecurity in the sense of reduced income (viewed from a partial equilibrium perspective in the context of agriculture) and in terms of self-sufficiency when analyzed from an economy-wide perspective. Panda and Ganesh-Kumar (2009) also used a CGEmodel to assess the impact of trade reforms on food security in India. The study found that an increase in real GDP or poverty reduction that might result from trade reforms did not necessarily improve the food security and/or nutritional status of the poor in India.

Similarly, Abdullateef and Ijaiya (2010) employed a CGE model to estimate two distinct trade regimes (regulated/restricted versus more open trade regime) in Nigeria with respect to food security. They found that trade reforms may have reduced commitment to improved capacity for self-sufficiency, thereby inducing reliance on food imports. They noted that liberalization did not facilitate the fundamental problem of food production, let alone other dimensions of FS.

Chandran (2010) utilized cross-tabulations to examine trade complementarity and similarity between India and ASEAN countries, using data covering the period of 1990 to 2009. His findings suggested that India has a fairly high comparative advantage and her agricultural trade intensity is relatively high with majority of the ASEAN countries except Singapore and Brunei. Likewise, Bezuneh and Yiheyis (2012) in a panel data econometric analysis of trade liberalization episodes in the 1980s and 1990s in some selected African countries reported that the effect of trade liberalization on food security, as measured by per capita daily energy supply, was negative.

A review of 34 relevant studies by McCorriston *et al*. (2013) found 13 studies suggesting a positive outcome, 10 negative, and 11 mixed. The authors attribute this to the different types of food security measures utilized and the estimation methods employed. They also noted that some of the studies did not control for other changes that might have occurred simultaneously during the process of liberalization. This obviously led to unjustifiable ascription of observed differences in food security indicators solely to a given trade policy reform.Pieters, Guariso and Vandeplas (2013) investigated the food implications of trade reforms in 37 developing countries representing liberalization episodes with dummy variables. The curious cases of increasing (decreasing) total food availability in the face of declining (booming) domestic production were found out. Thus, they classified the countries into those pursuing self-reliance or self-sufficiency in food security.

Mesfin and Zelealem (2014) assessed the effect of trade episodeson per capita daily dietary energy supply (DES) using a panel data covering 37 developing countries. The results were mixed in that improvements (substantial/marginal) were recorded in some countries, deterioration in others and imprecise direction of change in some others. Salvatici (2014) also assessed the impact of trade policy changes on food security, using a non-parametric matching technique, namely the Generalised Propensity Score (GPS) to address the self-selection bias and analyze heterogeneity in treatment (commodities) as well as in outcome (dimensions of food security). The results showed that both discrimination against agriculture and 'excessive' support compromise food security.

Observably, owing to the influence of the trade liberalization models, attention has largely been limited to just one or some of the dimensions of food security in Nigeria especially food availability which is only necessary but insufficient condition for sustainable food security. This study therefore considers a multi-dimensional model of food security by utilizing a dynamic modelling approach that caters for the peculiar dynamics of developing economies like Nigeria which CGE models and descriptive analysis that dominate the

methodological literature did not cater for. The findings of this study are expected to contribute to food security policy design and implementation in Nigeria.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The methodology of this study is informed by objectives of the study derived from the gaps found in the recent theoretical and empirical insights on the trade-food security linkage observed in the literature. Following this introductory remark, the analytical framework, model specification, estimation techniques and data issues are presented.

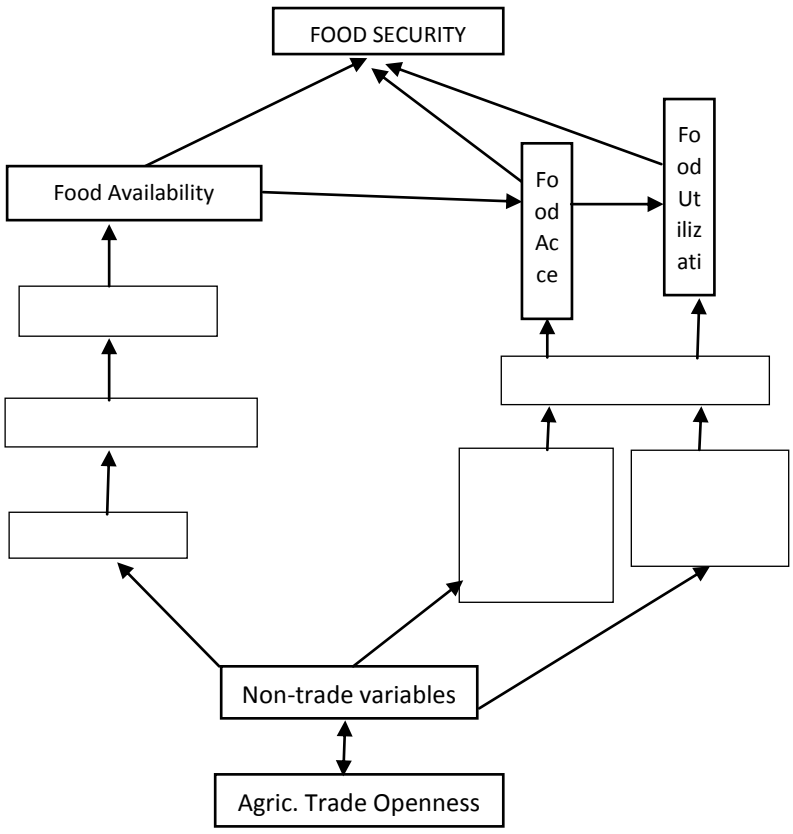
3.2 Analytical Framework

Understood from the food security models and the trade theories, it is noteworthy that food security is determined by an interplay of a number of factors. Therefore, an assessment of the impact of trade intensity on food security must consider the existing policy and institutional environment, agro-climatic constraints, and level of physical and human capital which tend to influence the extent towhich trade openness affects food security.This is based on the fact that even if increases in aggregate agriculture production andnet incomes do result from trade adjustments, it does not follow that thefood security of the people will

improve.This is because the distribution of benefits associated with agriculture trade may not favour vulnerable groups.

Since the theoretical literature on agricultural trade-food security linkage does not capture the relevant linkages explicitly, this study makes a systematic choice of relevant control variables informed by previous studies and peculiarities of the Nigerian economy. This largely follows Porter's Diamond predicated on emerging market realities of international trade such as monopolistic competition and oligopoly[4] as against perfect competition assumed by the Ricardian and factor proportions models. The foregoing discussion informs the framework presented in figure 4.

Figure 4: Schematic Illustration of the Trade Openness-Food Security Nexus



Source: Author's initiative

Figure 4 shows that openness and non-trade variables constantly interact to influence the dimensions of food security through natural and human endowments. The thrust of the

[4] Characterized by market failure and influence of powerful rent-seeking participants, forestalling level-playing relations.This is buttressed by the paradoxical fact that nations all over the world still employ some measures of trade restriction despite the multilateral agencies' (such as World Bank, IMF and WTO) clamour for free trade.

growth channel is captured by the extent to which agricultural financing proxied by budgetary allocations to agricultural sector interact with trade openness to determine food availability. Real GDP which portrays macro-economic conditions, agricultural land being a natural endowment, annual rainfall which captures the climatic conditions are also considered as control variables in food availability model. The price transmission channel posits that food access is dependent upon variables that determine the affordability of food items (See Diaz-Bonilla and Ron, 2010). Therefore, the interaction of such variables as agricultural credit, real exchange rate that determines the value of naira, per capita income that captures the average people's purchasing power vis a vis consumer price index is analyzed under accessibility. Government expenditures on health and education contribute to food utilization capacity of the people and this is illustrated in the schema.

3.3 Model Specification

The model relied upon is drawn from the specifications of Ugagu (2012) and Anowor, Ukweni and Martins (2013). However, our model differs from the aforementioned in that it utilizes agricultural trade openness which indicates the impact of agricultural sector instead of general trade openness proposed by Sachs and Warner (1995) obtained by dividing the sum of total exports and imports by the economy-wide GDP. Furthermore, per capita food supply variability is used as food availability measure which has a direct impact on food security compared with the food availability metric used by Ugagu (2012) and Anowor et al. (2013). The model is specified as a system of three equations according to the objectives of the study as follows:

$$FAV = f(ADOP, RGDP, AFN, AL, RNF) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 3.1$$

$$FAC = f(ADOP, EXCH, CPI, ACR, RD) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 3.2$$

$$FUT = f(ADOP, RGDP, HLTH, EDF) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 3.3$$

These translate to the following econometric models:

$$LogFAV = \alpha_0 + \alpha_1 LogADOP + \alpha_2 LogRGDP + \alpha_3 LogAFN + \alpha_4 LogAL + \alpha_5 LogRNF + \varepsilon_1 \quad 3.4$$

$$LogFAC = \beta_0 + \beta_1 LogADOP + \beta_2 LogEXCH + \beta_3 LogCPI + \beta_4 LogACR + \beta_5 LogRD + \varepsilon_2 \quad 3.5$$

$$LogFUT = \delta_0 + \delta_1 LogADOP + \delta_2 LogRGDP + \delta_3 LogHLTH + \delta_4 LogEDF + \varepsilon_3 \quad 3.6$$

Where FAV denotes food availability proxied by per capita food supply variability. FAC and FUT stand for food access and food utilization, respectively and they are accordingly measured by number of the undernourished and under five anemic prevalence respectively. ADOP is agriculture degree of openness. It is obtained by dividing the sum of agriculture exports and imports by agriculture share of GDP. EXCH denotes real exchange rate. AL and RNF are arable land irrigated and annual rainfall respectively. HLTH and AFN stand for expenditures on health and agricultural sectors, respectively. Other variable definitions are as follows: agricultural credits (ACR), consumer price index (CPI), real GDP (RGDP), road density per 100 square kilometers (RD). The α_i's, β_i's, and δ_i's are the parameters to be estimated, while ε_i's capture the stochastic error terms.

A positive association between real GDP and food security is expected due to the positive impact of national income on food production and of household income on food expenditure (Diaz-Bonilla and Ron, 2010). Agricultural landis also expected to positively contribute to food security since access to land facilitates domestic supply and hence, foodavailability. Real exchange rate is expected to have a positive or negative influence on food security, depending on its strength as an indicator of the country's economic competitiveness. According to Smith and Haddad (2000) and Diaz-Bonilla and Rons (2010), government revenue from trade positively influence food security through their impact on agricultural financing and provision of agricultural and general infrastructure. However, the empirical results of past studies (such as Herath et al., 2014)show that the relationship between food security and trade openness could either be positive or negative, depending on the country's agricultural and net food trade

status. The foregoing discussion informs the expected behaviour of the coefficients as summarized in table 3.1.

Table 3.1: Apriori Expectations of Estimated Coefficients

Eqn	Coeff. 1	Coeff. 2	Coeff. 3	Coeff. 4	Coeff. 5
3.4	α_1 >/< 0	$\alpha_2 > 0$	$\alpha_3 > 0$	$\alpha_4 > 0$	$\alpha_5 > 0$
3.5	β_1 >/< 0	β_2 >/< 0	β_3 >/< 0	$\beta_4 > 0$	$\beta_5 > 0$
3.6	δ_1 >/< 0	$\delta_2 > 0$	$\delta_3 < 0$	$\delta_4 < 0$	$\delta_5 < 0$

3.4 Estimation Techniques

The empirical analysis started with preliminary tests such as trend analysis, correlations, descriptives and stationarity tests. Following these, the Pesaran et al (2001)'s bounds-testing approach to cointegration also known as the autoregressive distributed lag (ARDL) model was carried out. These are expected to facilitate the subsequent error correction model (ECM)-causality procedure relied upon to ascertain the causal link between agricultural trade openness and the various dimensions of food security.

3.4.1 Stationarity Tests

Augmented Dickey-Fuller (ADF) Unit Roots Test

TheADF test[5](Dickey and Fuller, 1979)is an augmented version of the Dickey–Fuller test for a larger and more complicated set of time series models. The ADF test is based on estimating the regression equation below:

$$\Delta y_t = \alpha_0 + \alpha_1 t + \phi y_{t-1} + \sum_{i=1}^{p} \square_i \Delta y_{t-p} + \varepsilon_t \quad \text{..... 3.4}$$

Where Δ is first difference operator, α_0 is an intercept or constant, α_1 is a trend term, p is a lag order of the autoregressive process, and ε_t is the error term. Imposing the constraints that $\alpha_0 = 0$, corresponds to modeling a random walk, and using the constraint that $\alpha_1 = 0$, corresponds to modeling a random walk with a drift. The null hypothesis is that the variables have unit roots against the alternative that they do not. The decision rule is anchored on the notion that the more negative the ADF statistic is, the stronger the rejection of the hypothesis that there is a

[5]The ADF test is based on a parametric correction for higher order correlation based on the assumption that the dependent variable follows an AR(p) process and adding p lagged difference terms of the dependent variable to the right hand side of the test regression specified above.

unit root at some confidence level. Specifically, if the test statistic is less than the Dickey–Fuller critical value, then the null hypothesis is rejected and no unit root is present.

Phillips–Perron (PP) Unit Root Test

Phillips and Perron (1988) developed a unit root test that is used to test the null hypothesisthat an underlying series is integrated of order 1. It builds on the Dickey–Fuller test of the null hypothesis that $\rho = 0$. The test regression for the PP test is:

$$\Delta y_t = \alpha_0 + \alpha_1 t + \rho y_{t-1} + u_t \quad \text{..... 3.5}$$

Where Δ is the first differenceoperator. Like the augmented Dickey–Fuller test, the Phillips–Perron test addresses the issue that the process generating data for y_t might have a higher order of autocorrelation than is admitted in the test equation, thereby making y_{t-1} endogenous and thus invalidating the Dickey-Fuller t-test. Whilst the ADF test addresses this issue by introducing lags of Δy_t as regressors in the test equation, the PP test makes a non-parametriccorrection to the t-test statistic[6].

3.4.2 Cointegration Procedures

Bounds-Testing Approach to Cointegration

The E-G and Johansen and Juselius cointegration approaches is applicable only if the variables involved are integrated of the same order and some other restrictive conditions. For example, they are also limited by the fact that residuals are utilized in the regression which cannot be relied upon because they are subject to arbitrary changes (Pesaran, Shin and Smith, 2001). To analyze the long-run relationships and short run dynamic interactions among the variables of interest, the study therefore employs the multivariate cointegration approach developed by Pesaran et al (2001) and popularly known asAutoregressive Distributed Lag (ARDL) techniques of cointegration[7].

[6]The advantages of the PP tests over the ADF tests are; that the PP test is robust to general forms of heteroscedasticity in the error term u_t and that the user does not have to specify lag length for the test regression.

[7]This is a general vector autoregressive (VAR) model given as:$\Delta z_t = \boldsymbol{\alpha}_0 + \boldsymbol{\alpha}_1 t + \Pi z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \, \Delta z_{t-i} + \varepsilon_t$

The technique is applicable irrespective of whether the regressors are purely I(0), purely I(1), or are a mixture of both. In fact, it is not even necessary to check the order of integration of the variables prior to testing the existence of a level relationship amongst them (Pesaran et al., 2001: 315). The technique generates unbiased estimates of the long-run model[8] (Harris and Sollis, 2003). The bounds testing procedure is also robust for small sample study in that it is relatively more efficient (Tang and Nair, 2002). Furthermore, the approach is possible even when the explanatory variables are endogenous (Alam and Quazi, 2003: 93).

The estimation tests for the existence of a long-run relationship among the variables by conducting F-test for the joint significance of the long-run coefficients. Two sets of critical values for a given significance level are determined (Pesaran et al., 2001). The lower bound based on the assumption that the variables in the model are integrated of order zero, while the upper bound assumes that the variables are integrated of order one. The null hypothesis of no cointegration is rejected when the value of the test statistic exceeds the upper critical bounds value while it is accepted if the F-statistic is lower than the critical bounds value. Otherwise, the cointegration test is inconclusive.

3.4.3 Error Correction Model (ECM)-Causality Framework

The Granger causality (1969)'s shortcomings of specification bias and spurious regression (Engel and Granger, 1987) is resolved by implementing the Engle and Granger (1987)'s error correction procedure to determine the speed of adjustment of the variables from the short-run processes to their long-run processes. Once a co-integrating relationship is ascertained, the Granger representation theorem is relied upon to estimate the error-correction model (ECM) specified as follows: $\Delta y_t = \gamma_0 + \gamma_1 t + \pi \varepsilon_{t-1} + \sum_{i=1}^{m} \varphi_i \, \Delta Y_{t-i} + \sum_{i=0}^{m} \psi_i \Delta F_{t-i} + v_t$ ……. 3.6

[8]It is pertinent to note that only one long run relationship exists between the dependent variable and the explanatory variables within the context of this approach (Pesaran, Shin and Smith, 2001, assumption 3).

Where y_t is dependent variable, F is a vector of explanatory variables, π denotes the short run adjustment parameter, $\varepsilon_{t-1}$is the equilibrium error lagged one-period, v_t a stationary process with zero mean and m is the lag order in the short-run relationship selected with the aid of Akaike and Schwarz information criteria, with a maximum lag order of 6.

The second stage of ARDL approach is to estimate the coefficients of the long run cointegrating relationship and the corresponding ECT as specified below:

$$\Delta LogPFSV_t = \alpha_{01} + \alpha_{11} + \sum_{i=1}^{p} \alpha_{2i}\Delta Log(ADOP_{t-i}) + \sum_{i=1}^{q} \alpha_{3i}\Delta Log(AFN_{t-i}) + \sum_{i=1}^{r} \alpha_{4i}\Delta Log(AL_{t-i}) + \sum_{i=1}^{s} \alpha_{5i}\Delta Log(RNF_{t-i}) + \sum_{i=1}^{t} \alpha_{5i}\Delta Log(RGDP_{t-i}) + \theta_{11}(ECT_{t-1}) + \varepsilon_{1t} \quad \text{..... } 3.7$$

$$\Delta LogUNR_t = \alpha_{02} + \alpha_{12} + \sum_{i=1}^{p} \alpha_{2i}\Delta(UNR_{t-i}) + \sum_{i=1}^{q} \alpha_{3i}\Delta(ADOP_{t-i}) + \sum_{i=1}^{r} \alpha_{4i}\Delta(EXCH_{t-i}) + \sum_{i=1}^{s} \alpha_{5i}\Delta(CPI_{t-i}) + \sum_{i=1}^{t} \alpha_{6i}\Delta(ACR_{t-i}) + \sum_{i=1}^{u} \alpha_{7i}\Delta(RDS_{t-i}) + \theta_{21}(ECT_{t-1}) + \varepsilon_{2t} \quad \text{.....} 3.8$$

$$\Delta LogU5AP_t = \alpha_{03} + \alpha_{13} + \sum_{i=1}^{p} \alpha_{2i}\Delta(U5AP_{t-i}) + \sum_{i=1}^{q} \alpha_{3i}\Delta(ADOP_{t-i}) + \sum_{i=1}^{r} \alpha_{4i}\Delta(HLTH_{t-i}) +$$

Where θ_{11}, θ_{12}, θ_{13}, are the magnitudes of errors corrected each period which must be negative, absolutely less than unity and statistically significant to attain long-run equilibrium. ECT_{t-1} is error correction term which is the speed of adjustment to long-run equilibrium. The lagged error correction term (ECT_{t-1}) derived from the ECT model is an important element in the dynamicsof a cointegrated system as it allows for adjustment back to the long-term equilibrium relationship given a deviation in the short-term.

3.5 Diagnostic Tests

To check for possible interdependence and uneven distribution of the parameters and the residuals of the dynamic model, some diagnostic tests were carried out. The Breusch-Godfrey serial correlation (Lagrangian Multiplier) test was employed to test for the presence of serial correlation. The Jarque-Bera test was used to test for normality of the residuals while the Breusch-Pagan-Godfrey procedure wasrelied upon to test for heteroscedasticity. Furthermore, stability test of the short run coefficients using the cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ).

3.5 Data Issues

The study utilized secondary data obtained from a number of formal institutional sources, including: Central Bank of Nigeria (CBN), National Bureau of Statistics (NBS), FAO's statistical portal (FAOSTAT), World Development Indicators (WDI), Federal Ministry of Agriculture and Rural Development (FMARD), Federal Ministry of Finance (FMFN), World Integrated Trade Solution (WITS). A summary of data issues is presented in Table 1.2 in appendix I.

CHAPTER FOUR

PRESENTATION AND ANALYSIS OF RESULTS

4.0 Introduction

In this chapter, the research findings are discussed. It begins by presentingpre-estimation diagnostics which include descriptive statistics of the variables, trend analysis, pairwise correlation matrix and unit root tests. Then, the main estimation results of ARDL cointegration, the associated diagnostic tests andfinally, the ECM-causality results are presented and discussed accordingly.

4.1Model 1: Impact of Agricultural Degree of Openness on Food Availability in Nigeria $\{FAV = f(ADOP, RGDP, AFN, AL, RNF)\}$

4.1.1 Pre-Estimation Diagnostics

(i) Descriptive Statistics of the Variables

In order to highlight the implications of the distributional properties of the key variables, descriptive statistics were computed and reported in Table 4.1. From the table, the mean values

of FAV, FAC and FUT measures are respectively 42.647 kcal/capita/day, 13.34 million and 75.07 percent. That the FAV and FUT measures exhibit negative skewness shows that they require urgent attention to check the trend as the distributions are clustered around the maximum values. The positive skewness portrayed by the FAC series indicates gradual ease in the number of the undernourished. However, its high mean value of 13.34 million is a source of concern. The FUT series (percentage of under-five children affected by anaemia) ranges from 71.0 percent to 77.8 percent. By implication, the level of undernourishment amongst children for a period of 35 years (1981 - 2015) in Nigeria remains extremely high.

The ADOP series ranges from 0.048 to a maximum value of 0.225 in year 2011, according to Figure 4.4, which shows the increase in food imports that followed the global food crisis of 2008 to 2011. The AL series shows that the proportion of arable land equipped with irrigation facilities fluctuates within abysmal levels of 0.7 percent to 1.2 percent. This is an indication of the level of commitment of the stakeholders to food security. The foregoing is an indication of underutilization of abundant rainfall over the period as the RNF series ranges from a minimum value of 37460.30 millimetres to a maximum value of 66013.50 millimetres.

Table 4.1: Descriptive Statistics (sample period: 1981-2015)

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
FAV	42.647	40.50	76.00	7.00	21.09	-0.0122	1.747
FAC	13.34	11.70	20.90	8.70	4.01	0.572	1.829
FUT	75.07	75.95	77.80	71.00	2.26	-0.624	1.835
ADOP	0.087	0.084	0.225	0.048	0.036	1.721	7.466
RGDP	30723.60	22332.87	69023.93	13779.26	17308.63	0.949	2.519
AFN	13.958	2.89	65.4	0.01	18.57	1.266	3.542
AL	0.86	0.8	1.2	0.7	0.11	0.830	3.851
RNF	55540.33	55894.90	66013.50	37460.30	6324.60	-0.727	3.319
EXCH	83.34	107.02	193.28	2.021	64.38	-0.0432	1.351
CPI	61.97	36.73	180.15	20.96	49.241	1.0712	2.846
ACR	2850346	241839	12456251	24654.9	4076162	1.099	2.565
RDS	18.22	20.90	21.60	11.80	3.92	-0.655	1.586
HLTH	49.69	4.74	257.72	0.04	77.85	1.558	4.183
EDF	100.21	50.79	390.42	0.23	124.85	1.223	3.110

Source: Author's Computation

It is interesting to note that the ACR, AFN, HLTH and EDF all exhibit positive skewness. This is an indication that most of the FS-related financial commitments are clustered around the minimum values. The RDS series displays the limited physical access to food as it ranges from 11.80 to just 21.60 kilometres per 1000 kilometres square. It is pertinent to note that the standard deviations of the variables are not within close range. This informs the logging of the variables for onward estimations.

(ii) Correlation Matrix

Pairwise correlation analysis was also conducted on the variables and reported in Table 4.2. The foremost associations of interest in Table 4.2 are the negative correlation coefficients between ADOP and all the three dimensions of food security, FAV, FAC and FUT. Similarly, agricultural financing (AFN), agricultural credit (ACR) as well as exchange rate of the Naira are negatively correlated with all the measures of food security chosen for this study. It is not surprising that the correlations between RGDP and ACR, AFN, CPI, EXCH, EDF and HLTH is very high as they are monetary aggregates. This seeming multi-collinearity is harmless in that the variables are not the main explanatory variables and their correlations with the dependent variables and the main explanatory variable (ADOP) are less than 50%.

Table 4.2: Pairwise Correlation Matrix of the Variables

	ACR	ADOP	AFN	AL	CPI	EDF	EXCH	FAC	FAV	FUT	HLTH	RDS	RGDP	RNF
ACR	1													
ADOP	0.177	1												
AFN	0.724	0.172	1											
AL	0.304	0.298	0.191	1										
CPI	0.954	0.187	0.741	0.3446	1									
EDF	0.915	0.304	0.754	0.324	0.97	1								
EXCH	0.828	0.073	0.75	0.141	0.859	0.828	1							
FAC	-0.698	-0.047	-0.715	0.109	-0.708	-0.695	-0.903	1						
FAV	-0.416	-0.206	-0.466	0.143	-0.373	-0.38	-0.662	0.765	1					
FUT	-0.947	-0.182	-0.778	-0.31	-0.965	-0.943	-0.898	0.79	0.498	1				
HLTH	0.925	0.329	0.743	0.332	0.971	0.976	0.815	-0.667	-0.365	-0.936	1			
RDS	0.538	0.104	0.582	-0.304	0.558	0.553	0.792	-0.927	-0.746	-0.609	0.521	1		
RGDP	0.954	0.159	0.768	0.238	0.986	0.958	0.904	-0.795	-0.464	-0.98	0.952	0.659	1	
RNF	0.594	0.097	0.632	-0.307	0.627	0.639	0.691	-0.785	-0.564	-0.65	0.623	0.802	0.705	1

Source: Author's Computation

(iii) Unit Root Tests

All the variables were tested for unit root based on the Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests under the null hypothesis that the variables are not stationary at 5% level of significance. Extracts of the stationarity test results arepresented in Table 4.3. A more detailed version of the test results are presented inTables 2.2.1 and 2.2.2 in the appendix.The test results showedthat some of the variables are I(0), while others are I(1).After establishing the stationarity properties of the variables, Pesaran *et al.* (2001) bounds-testing co-integration procedure was used to test for co-integration among the variables.

Table 4.3: Unit Root Tests of the Variables (period: 1981-2015)

Variables	ADF			PP		
	Level	**First difference**	**Remark**	**Level**	**First difference**	**Remark**
LACR	-2.296442	-5.712912*	I(1)	-2.338515	-5.732803*	I(1)
LADOP	-4.011012**	-8.782818	I(0)	-4.038976**	-9.609695	I(0)
LAFN	-2.340535	-6.520146*	I(1)	-2.169774	-13.84841**	I(1)
LAL	-2.643723	-5.663572*	I(1)	-2.720293	-5.772809*	I(1)
LCPI	-1.528947	-4.930074*	I(1)	-1.478636	5.018193*	I(1)
LEDF	-3.498293***	-5.449804	I(0)	-3.441801***	-13.07890	I(0)
LEXCH	-1.039485	-5.395569*	I(1)	-1.021160	-5.868398*	I(1)
LFAV	-3.957668**	-5.604330	I(0)	-2.123919	-9.971358*	I(1)
LFAC	-0.944859	-4.282866*	I(1)	-1.428452	-4.282866*	I(1)
LFUT	-1.774843	-6.985663*	I(1)	-1.707150	-6.886643*	I(1)
LHLTH	-0.669891	-5.185230*	I(1)	-4.503438*	-17.69143	I(0)
LRDS	-1.909632	-6.573946**	I(1)	-0.877512	-3.966964**	I(1)
LRGDP	-2.219403	-3.602984**	I(1)	-2.311335	-3.461881***	I(1)
LRNF	-3.824416**	-8.783597	I(0)	-3.882305**	-11.27456	I(0)

*Note: *, **, *** denotes rejection of the null hypothesis at 1%, 5% and 10% respectively. The ADF and PP critical values are Mackinnon (1996) one-sided p-values.*

Source: Author's Computation

(iv) Trend Analysis of Relevant Variables

Line graphs were plotted on the variables in model one independently and in groups to give some insights into the trajectory of the variables over the years. These are shown in Figures 5 to 8. According to Figure 5, per capita food supply variability used as proxy for food availability used to be high and stable in early 1980's before adoption of SAP and the consequent trade liberalization, after which the FAV metric began a downward and fluctuating trend.

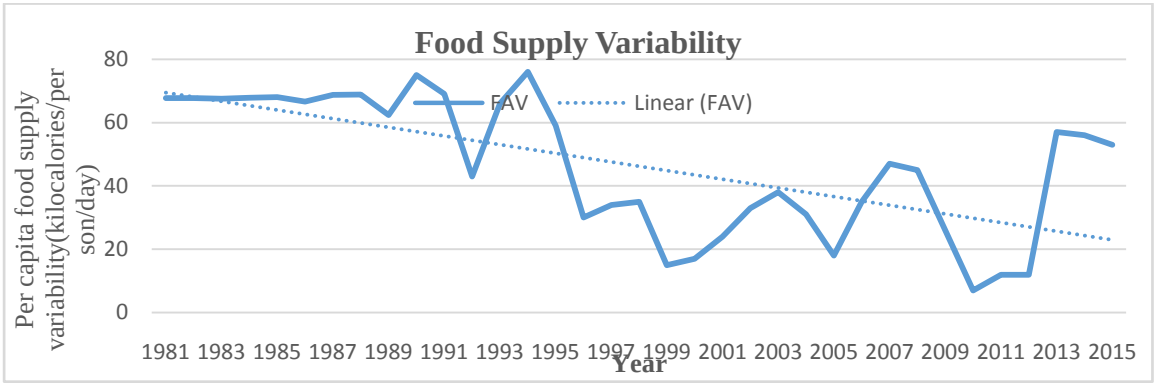


Fig. 5: Food Availability Measure

Source: FAOSTAT

In Figure 6, the distribution of agricultural degree of openness (ADOP), the main independent variable of the study, is illustrated,. The downward trend in the pre-1986 period is an indication of the then protectionist trade regimes. The graph began to fluctuate with spikes after 1986 and reached its peak during the period 2010 to 2012. The chart denotes slight upward trend albeit with small variations. The greatest spike of 2011 to 2012 is an indication of the strategy of allowing more food imports which increased by more than 300% compared to 2010. This was meant to mitigate the impact of the global food crisis at the time.

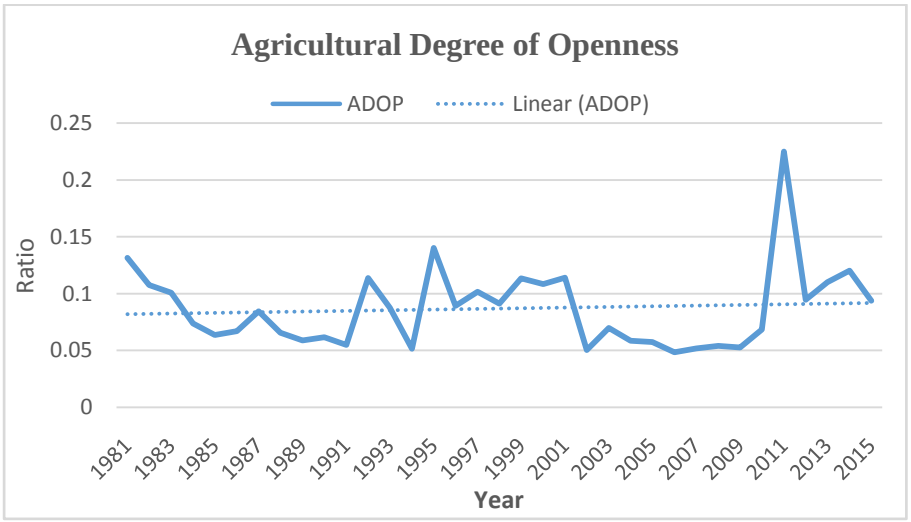


Fig. 6: Agricultural Degree of Openness

Source: Author's computations based on data from comtrade and WITS

Figure 7 depicts the percentage of arable land which are equipped with irrigation facilities in Nigeria over the years. The series ranges between abysmal levels of 0.7% and 1.2%. This is a clear indication of low commitment of stakeholders in Nigeria to food security.

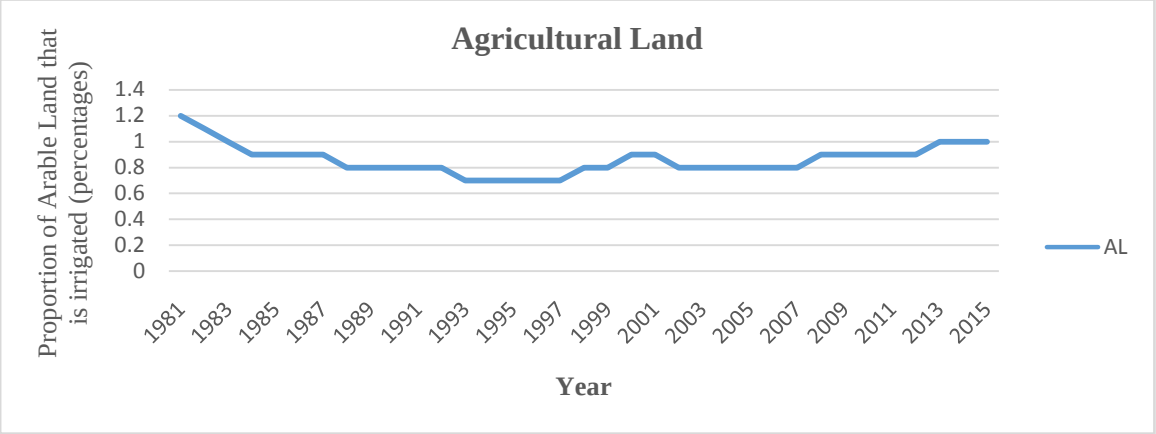


Fig. 7: Agricultural Land Irrigated

Source: FAOSTAT

Figure 8 shows that the volume of rainfall in Nigeria has been increasing during the period considered. This is depicted by the upward trend exhibited by the graph. But since dry season is usually longer than rainy season, natural rainfall should have been complemented with irrigation facilities to sustain all-year round production, and in turn, sustainable food security. However, this has not been the case as obvious from figure 4.6. Hence, the seasonal alternation of glut and scarcity associated with food price swings that compromise sustainable food security.

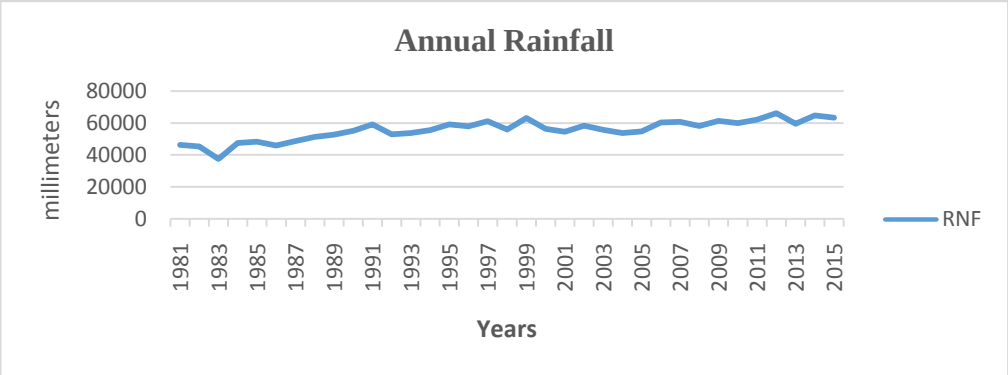


Fig. 8: Annual Rainfall

Source: FAOSTAT

4.1.2 Auto Regressive Distributed Lagged(ARDL) Cointegration Results

(i) Lag Selection Criteria

After establishing the stationarity properties of the variables, the foremost step in the estimating the Pesaran *et al.* (2001)'s ARDL bound testing co-integration procedure is to find out the optimal initial lag lengths of the variables. For this model, Table 4.5 reveals that

the optimal lag length of the variables is four based on all the selection criteria. Hence, model one was estimated using four lags.

Table 4.4: Lag Selection Criteria

Endogenous variables: LFAV, LADOP, LRGDP, LAFN, LAL, LRNF

Lag	LR	FPEAICSC	HQ		
0	NA	1.73e-07	1.457866	1.735412	1.548339
1	215.2177	2.36e-10	-5.186958	-3.244136	-4.553646
2	36.49137	4.21e-10	-4.891675	-1.283579	-3.715526
3	36.65328	4.87e-10	-5.623535	-0.350162	-3.904547
4	61.74794*	-2.09e 12*	-13.59228*	-6.653630*	-11.33045*

*Source: Author's Computation. Note: * indicates lag order selected by the criterion. LR: Sequential modified LR test statistics (each at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: schwarz information criterion, HQ: Hannan-Quinn information criterion*

(ii) Long-Run Analysis – ARDL Bound Test for Cointegration

In order to ascertain the long run relationship among the variables, the study employed ARDL bound test approach to cointegration developed by Pesaran *et al.* (2001). This approach starts by estimating the unrestricted error correction model from which the restricted model is obtained. The result of the restricted model is presented in table 4.6.

Table 4.5: Autoregressive Distributed Lag Cointegration Estimates

Dependent Variable: D(LFAV)

Variable	Coefficient	Prob.
C	96.68969	0.0021
D(LFAV(-2))	0.135940	0.5372
D(LADOP(-1))	-1.383978	0.0023

D(LADOP(-2))	-0.346943	0.2141
D(LRGDP(-1))	2.575283	0.3942
D(LRGDP(-3))	5.976006	0.0330
D(LAFN(-1))	0.202642	0.1207
D(LAFN(-2))	0.140392	0.3244
D(LAFN(-3))	0.307881	0.0446
D(LAL(-3))	6.040063	0.0103
D(LRNF(-1))	8.474934	0.0028
D(LRNF(-2))	7.184286	0.0017
D(LRNF(-3))	4.000700	0.0329
LFAV(-1)	-0.276476	0.2130
LADOP(-1)	1.974303	0.0012
LRGDP(-1)	1.231809	0.0199
LAL(-1)	-3.115150	0.0396
LRNF(-1)	-9.562693	0.0028
R-squared	0.743330	
F-statistic	2.214624	0.0757
D-W stat	1.791260	

Source:Author's Computation using Eviews 8

The result of the bound test for cointegration presented in Table 4.7 shows that the bounds F-statistics value of 4.56is greater than the critical upper bound F-statistics value of4.01 at K= 4 and at 5% level of significance. Therefore, we reject H_0 and conclude that the variables are cointegrated, meaning that the variables have a long run equilibrium relationship. This is not invalidated by the fact that bounds t-statistic value of -1.31 is less in absolute terms than the critical bounds t-statistics value of -3.99 at K = 4 and at 5% level of significance.

Table 4.6: Bounds Test for Cointegration

Test Statistic	**Value**	**Prob.**
F-statistic	4.56	0.0127
Chi-square	22.79	0.0004
t-statistic	-1.31	0.213
Chi-square	1.72	0.19

Asymptotic critical value bounds: Case III: Unrestricted intercept and no trend

0.10		0.05		0.01	
K = 4	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
F- Statistics	2.45	3.52	2.86	4.01	3.74	5.06
t- Statistics	-2.57	-3.66	-2.86	-3.99	-3.43	-4.60

Source: Pesaran et al. (2001), p. 300 - 303

Long-run relationships having been established among the variables, the long runequation derived from Table 4.6 is presented in equation 4.1.

$$Log(FAV)_t = 96.69 + 1.97Log(ADOP)_{t-1} + 1.23Log(RGDP)_{t-1} - 3.12Log(AL)_{t-1} - 9.56Log(RNF)_{t-1} \ldots\ldots\ldots\ldots 4.1$$

(0.0021) (0.0012) (0.0199) (0.0396) (0.0028)

Equation 4.1 shows that in the long run,ADOP impacts positivelyand significantly on the FAV measure in Nigeria at 5% level of significance.As ADOP increases by 1%, FAV increases by 1.97% in the long run. Therefore, this serves as evidence that in the long run, the per capita food supply variability will respond by about 2% to a percentage increase in ADOP. This finding is consistent with Abdullateef and Ijaiya (2010) which also showed that trade openness would exacerbate food supply volatility in Nigeria. But this result is inconsistent with Oyejide et al. (2006) which did not find any long-run relationship between trade policy and food supply in Nigeria. These differences may be attributed to the varying food supply measures used and the specificity of ADOP compared to the general degree of openness used in both studies.

(iii) Short run Analysis – Parsimonious Error Correction Model

In order to obtain the parsimonious error correction model, the study employed Hendry-type general-to-specific approach by removing the highest insignificant coefficients from the general error correction model presented in appendix 3.1a. The parsimonious error correction model is presented in Table 4.8.

The ECT in Table 4.7 shows that the short-run disequilibrium will converge to equilibrium in the long run at a speed of about 48%. The result also shows that ADOP has negative but insignificant impact on GDP in Nigeria in the short run at 5% level of significance.A percentage increase in ADOP in the previous year will cause FAV in the current year to decrease by about 23.5%. This implies that ADOP in the current year will have negative but insignificant impact on FAV next year. This finding is inconsistent with Oyejide et al. (2006) which shows that DOP has negative impact on short-run food supply changes in Nigeria; but consistent with Abdullateef and Ijaiya (2010) which noted that DOP has negative but statistically insignificant impact on FAV.

The model passed diagnostic tests. The tests show absence of serial correlation and hetero-skedasticity. The normality test (Jarque-Bera) also shows that the residuals of the model are normally distributed and Ramsey RESET Test shows that the model is correctly specified. Finally, CUSUM and cumulative sum of square (CUSUMSQ) tests of parameter instability reveals satisfactory plot at 5% level of significance.

Table 4.7: Parsimonious Error Correction Model

Dependent Variable: D(LFAV)

Variable	**Coefficient**	**Prob.**
C	-0.018565	0.8083
D(LADOP(-1))	-0.234791	0.2119
ECT(-1)	-0.479998	0.0082
R-squared	0.252444	

F-statistic	5.065399	0.012725
D-W stat	1.694240	

Serial Correlation LM Test		
F-statistic	0.966996	0.3926
Obs*R-squared	2.132082	0.3444

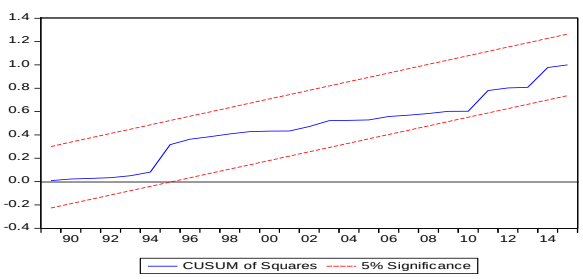
Heteroskedasticity Test: ARCH		
F-statistic	0.609778	0.5501
Obs*R-squared	1.289108	0.5249

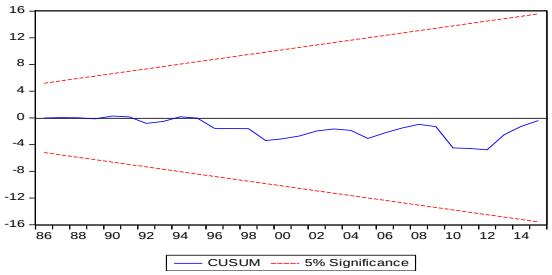
Normality Test		
Jarque-Bera	2.88043	0.236872

Specification Error (Ramsey RESET) Test		
F-statistic	0.815964	0.3766

Source: Author's Computation using Eviews 8

Parameter Stability Tests





In conclusion, the result is an evidence of long-run positive effect of ADOP on per capita food supply variability in Nigeria. In the short run, ADOP was found to have negative but statistically insignificant effect on FAV in Nigeria. In the next section, the study examines

the impact of ADOP on FAC proxied by number of the undernourished in Nigeria.

4.1.3 Error Correction Model (ECM)-Causality on Model One {Recall: $FAV = f(ADOP, RGDP, AFN, AL, RNF)$

Table 4.8 shows that there is a bidirectional causality between ADOP and food availability proxied by per capita dietary supply variability. The only difference in the two way causality is that ADOP granger causes FAV at 5% level of significance, while FAV granger causes ADOP at 1% level of significance. This implies that ADOP reacts to changes in FAV faster than FAV does to changes in ADOP. This is reflected by the respective values of the ECTs which are about 79.4% and 48%.

Table 4.8: Causality Test Based on Error Correction Model between Agricultural Degree of Openness and Food Availability in Nigeria
Equation: DLADOP 'cause' DLFAV

Dependent Variable: *DLFAV*			**Dependent Variable: *DLADOP***		
Variables	**Coefficient**	**t-Statistic**	**Variables**	**Coefficient**	**t-statistic**
Constant	-0.018565	-0.244744	**Constant**	0.079784	0.905174
D(LADOP(-1))	-0.234791	-1.275640**	***D(LFAV(-1))***	-0.155806	-1.32957*
ECT(-1)	-0.479998	-2.830669*	***D(LRNF(-***	1.536723	2.169868**
			ECT(-1)	-0.794106	-4.243882*
DW-Stat: 1.694240			***DW-Stat:*** 1.811696		

Source: Author's Computation

Note: * and ** depict significance at 1% and 5% levels respectively

4.2 Model 2: Impact of Agricultural Trade Openness on Food Access in Nigeria {$FAC = f(ADOP, EXCH, CPI, ACR, RD)$}

4.2.1 Trend Analysis of Relevant Variables

According to Figure 9, the number of Nigerian residents that are undernourished has generally been on the decrease. It is interesting to note that amidst this seemingly smooth downward trend which could be regarded as a positive development for food security, the major spike observed in the graph also took place in the period 1989 to 1991; an aftermath of the 1986 liberalization episodes in addition to the political uncertainty at the time.

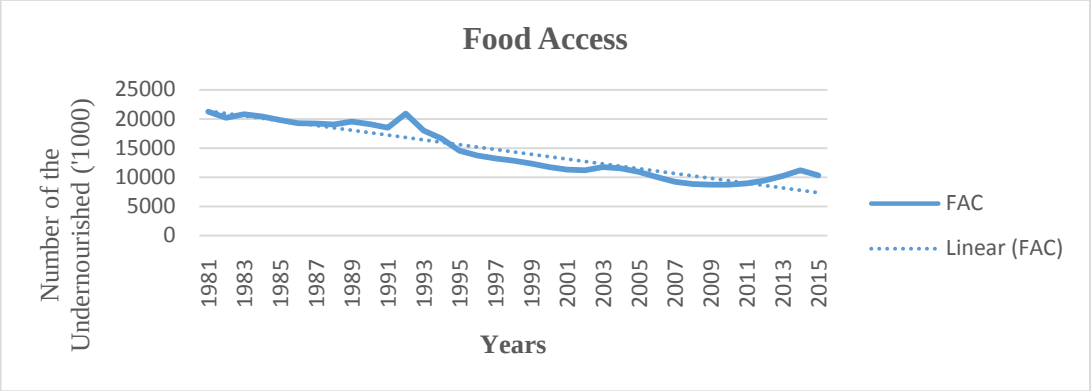


Fig. 9: Food Access Metric

Source: FAOSTAT

The trajectory of official exchange rate of the naira per US dollar over the years is illustrated in Figure 10. The figure clearly shows that the rate has been rising and a check on the trend is not in sight as Nigeria has failed to boost her export capacity over the years, depending on the volatile proceeds of oil. This no doubt affects food security negatively through the price channel as Nigeria is still largely dependent on food imports.

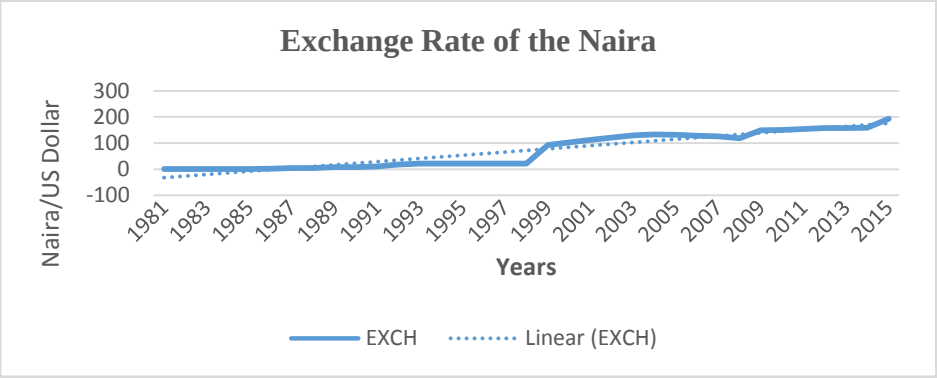


Fig. 10: Exchange Rate of the Naira

Source: CBN Statistical Bulletin, 2015

Figure 11 shows the road density per one thousand kilometres in Nigeria. The figure depicts that for the period from 1981 to 2015, road density in Nigeria hovers within abysmal levels as it ranges from 11.8 to 21.6 kilometres per 1000 square kilometres. This has the tendency of affecting physical access to food negatively. This is because farmers' and consumers' access to markets is constrained.

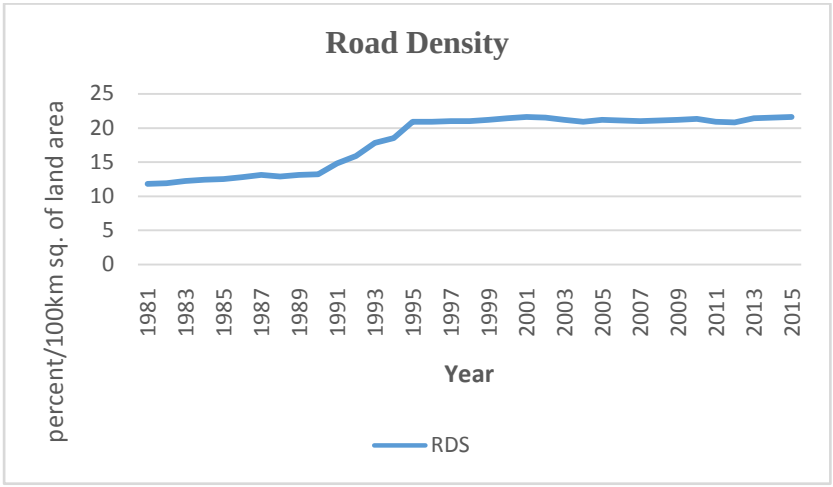


Fig. 11: Road Density

Source: FAOSTAT

The interactions of some public-sector financial commitments that have some bearing on food security are shown in Figure 12. It is noteworthy that agricultural credit (ACR) and agricultural financing (AFN) which have more direct relationship with food security are trailing behind budgetary allocations to health and education sectors. In fact, it is noticeable that ACR nearly fizzles out in the figure. It is interesting that all the variables display relatively upward trends in recent years. However, their contribution to food security is offset by rising prices of food and agricultural inputs.

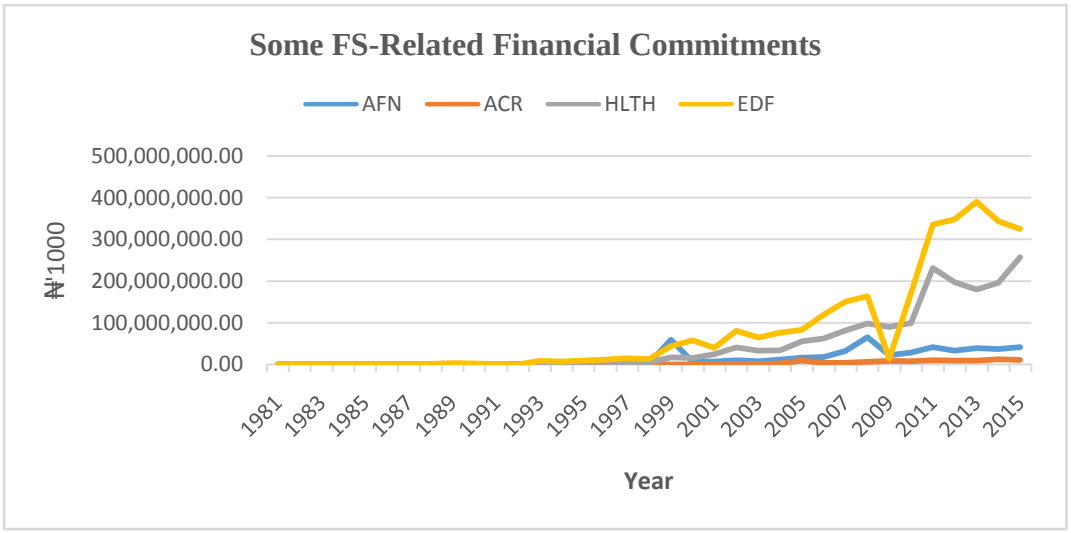


Fig. 12: Some Relevant Financial Commitments

Source: CBN's Statistical Bulletin, 2015

4.2.2Auto Regressive Distributed Lagged (ARDL) Cointegration Results

(i) Lag Selection Criteria

For the variables in this model, Table 4.9 shows that all the lag selection criteria suggested optimal lag length of four. Hence, model two was estimated with initial four lags and presented in Table 4.10.

Table 4.9: Lag Selection Criteria

Endogenous variables: LFAC, LADOP, LEXCH, LCPI, LACR, LRDS

Lag	LR	FPEAICSCHQ			
0	NA	4.48e-07	2.409301	2.686847	2.499774
1	307.1950	1.32e-11	-8.067909	-6.125088	-7.434598
2	35.17749	2.54e-11	-7.699634	-4.091537	-6.523484
3	36.44087	2.99e-11	-8.413792	-3.140420	-6.694804
4	53.89252*	4.75e-13*	-15.07330*	-8.134650*	-12.81147*

*Source: Author's Computation. Note: * indicates lag order selected by the criterion, LR: Sequential modified LR test statistics (each at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: schwarz information criterion, HQ: Hannan-Quinn information criterion*

(ii) Long-run Analysis – ARDL Bound Test for Cointegration

The ARDL general (unrestricted) long-run model is presented in appendix 3.2a. The restricted model obtained from the general (unrestricted) long-run model is presented in table 4.10.

Table 4.10: Autoregressive Distributed Lag Cointegration Estimates

Dependent Variable: D(LFAC)

Variable	Coefficient	Prob.
C	4.595914	0.0039
D(LFAC(-1))	0.758541	0.0086
D(LFAC(-2))	0.160234	0.5735

D(LFAC(-3))	0.195342	0.4278
D(LADOP(-1))	-0.086628	0.0043
D(LEXCH(-1))	-0.041750	0.1753
D(LEXCH(-2))	-0.022397	0.4519
D(LACR(-2))	0.015441	0.4782
D(LACR(-3))	0.035974	0.1246
D(LRDS(-1))	1.521679	0.0009
D(LRDS(-2))	-0.367695	0.3337
LFAC(-1)	-0.762785	0.0081
LADOP(-1)	0.100984	0.0080
LCPI(-1)	-0.160188	0.0488
LRDS(-1)	-0.612315	0.0013

R-squared	0.748249	
F-statistic	3.396773	0.01077
D-W stat 2.391769		

Source: Author's Computation using Eviews 8

Table 4.11 shows that the bound F-statistics value of 4.356 is greater than the critical upper bound F-statistics valueof 4.35 at K=3 and at 5% level of significance. Therefore, we reject H_0 and conclude that the variables are cointegrated. That is, the variables have long run (equilibrium) relationship. However, the bound t-statistic value of -3.04 falls in between the critical upper and lower bounds t-statistics value of -2.86 and -3.78 at K = 3 and at 5% level of significance. This is negligible.

Table 4.11: Bounds Test for Cointegration

Test Statistic	**Value**	**Prob.**
F-statistic	4.356	0.0170
Chi-square17.430.0016		
t-statistic	-3.04	0.0088
Chi-square	9.25	0.0023

Asymptotic critical value bounds: Case III: Unrestricted intercept and no trend

	0.10		0.05		0.01	
K = 3	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
F- Statistics	2.72	3.77	3.23	4.35	4.29	5.61

t- Statistics	-2.57	-3.46	-2.86	-3.78	-3.43	-4.37

Source: Pesaran et al. (2001), p. 300 - 303

The long run relationship drawn from table 4.10 is hereby presented in equation 4.2.

$$Log(FAC) = \underset{(0.0039)}{4.59} + \underset{(0.0080)}{0.101Log(ADOP)} - \underset{(0.0488)}{0.16Log(CPI)} - \underset{(0.0013)}{0.61Log(RDS)} \ldots\ldots\ldots\ldots\ldots 4.2$$

Equation 4.2 shows that ADOP has a positive and significant impact on the number of the undernourished, being the proxy for FAC, in Nigeria in the long run at 1% level of significance as indicated by the probability value.That is, a percentage rise in ADOPincreases the number of the undernourished by 10.1%. It is pertinent to note that an increase in the number of the undernourished implies reduced food access. This means that there exists long-run negative effect of ADOP on food access in Nigeria. This finding is consistent with Abdullateef and Ijaiya (2010) which also found that trade openness has negative impact on food access though theirs was a direct finding because they used a different metric for food access.

(iii) Short-Run Analysis – The Error Correction Model

Table 4.12 shows that the coefficient of error correction term is negative and statistically significant even at 1%. That is, the short-run disequilibrium will adjust to equilibrium in the long-run at a speed of about 46.3%. The result also shows that ADOP has negative but insignificant impact on FAC in Nigeria at 5% level of significance. The coefficient shows that a percentage increase in ADOP in the past one year will cause the number of the undernourished in the current year to decrease by about 4.1% which is only marginal. This finding is consistent with Abdullateef and Ijaiya (2010) which noted that trade openness has positive impact on food access in Nigeria.

Once again, the probability value of F-statistics (0.000498) indicates that the independent variables are jointly significant even at 1%. Similarly, the D-W statistic of 1.821897indicates that there is no autocorrelation in the model. Other diagnostic tests show that the model is not serially correlated, meaning that the residuals are independently

distributed. The model is also homoscedastic, correctly specified according to Ramsey RESET Test and the residuals arenormally distributed. Remarkably, the CUSUM and CUSUMSQ tests of parameter instability reveal satisfactory plot of the recursive residuals, thereby increasing the robustness of the results.

Table 4.12: Parsimonious Error Correction Model

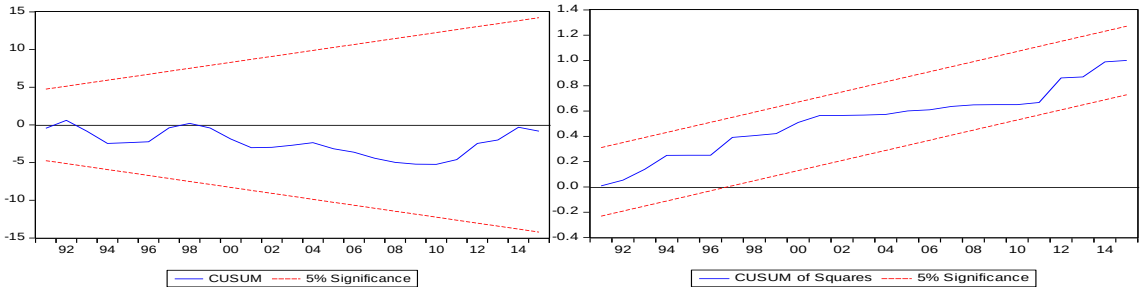
Dependent Variable: D(LFAC)

Variable	Coefficient	Prob.
C	-0.009442	0.3466
D(LFAC(-1))	0.549241	0.0018
D(LADOP(-1))	-0.040621	0.0453
D(LEXCH(-1))	-0.042577	0.1065
D(LRDS(-1))	0.898632	0.0036
D(LRDS(-2))	-0.640339	0.0153
ECT(-1)	-0.463227	0.0013
R-squared	0.593261	
F-statistic	6.077413	0.000498
D-W stat	1.821897	
Serial Correlation LM Test		
F-statistic	0.110590	0.8958
Obs*R-squared	0.304799	0.8586
Heteroskedasticity Test: ARCH		
F-statistic	2.796008	0.1299
Obs*R-squared	12.85027	0.1433
Normality Test		
Jarque-Bera	2.154238	0.340575

Specification Error (Ramsey RESET) Test		
F-statistic	2.903295	0.1013

Source: Author's Computation using Eviews 8

Parameter Stability Tests



The study therefore concludes that in the long-run, ADOP significantly increases the number of the undernourished in Nigeria, thereby worsening the country's food insecurity. In the short-run, ADOP reduces the number of the undernourished in Nigeria albeit insignificantly. In the next sub-section, the result of the model on the impact of ADOP on food utilization in Nigeria is presented and analyzed.

4.2.3 Error Correction Model (ECM)-Causality on Model Two {Recall:$FAC = f(ADOP, EXCH, CPI, ACR, RD)$}

A unidirectional causality from ADOP to food access proxied by the number of theundernourished is illustrated in Table 4.13. The coefficient of ADOP which is significant at 5% level shows that 1% increase in ADOP in a year will decrease FAC in the following year by about 4.06%. The coefficient of the ECT signifies that the short-run processes adjust to a long-run equilibrium at a speed of about 46.3%.

Table 4.13: Causality Test Based on Error Correction Model between Agricultural Degree of Openness and Food Access in Nigeria
Equation: DLADOP 'cause' DLFAC

Dependent Variable: *DLFAC*			**Dependent Variable: *DLADOP***		
Variables	**Coefficient**	**t-statistic**	**Variables**	**Coefficient**	**t-statistic**

C	-0.009442	-0.959364	***C***	-0.046754	-0.755670
D(LFAC(-1))	0.549241	3.492491*	***D(LFAC(-2))***	-1.533464	-1.454702
D(LADOP(-	-0.040621	-2.106874**	***ECT(-1)***	-0.818066	-4.551233*
D(LRDS(-1))	0.898632	3.214986*			
D(LRDS(-2))	-0.640339	-2.603569**			
ECT(-1)	-0.463227	-3.612137*			
DW-Stat: 1.821897			***DW:*** 1.746155		

Source: Author's Computation

Note: * and ** denote significance at 1% and 5% levels respectively

4.3 Model 3: Impact of Agricultural Degree of Openness on Food Utilization $\{FUT = f(ADOP, RGDP, HLTH, EDF)\}$

This section examines the impact of agriculture degree of openness on food utilization in Nigeria using time series data for the period 1981 to 2015.

4.3.1 Trend Analysis of Relevant Variables

Figure 13 illustrates the percentage of under-five children that are affected by anaemia, an undernutrition disease. This used as a proxy for food utilization in Nigeria. That the distribution ranges from a minimum of 71% to a maximum of 77.8% is an indication that food utilization status in Nigeria is low. It is interesting to note that this negative indicator of food utilization spiked and was highest during the period 1987 to 1988, and this commenced with the liberalization policy at the time.

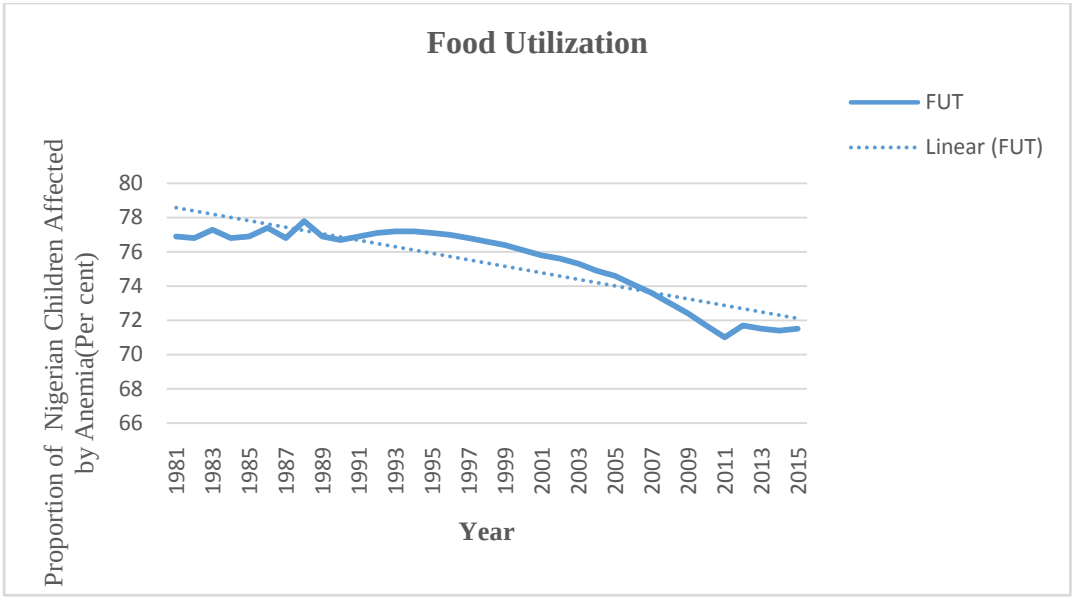


Fig. 13: Food Utilization Proxy

Source: FAOSTAT

4.3.2 Auto Regressive Distributed Lagged (ARDL) Cointegration Results

(i) Lag Selection Criteria

The result of lag selection procedure calculated from VAR model at level is presented in Table 4.14. The result shows that LR and SC suggested two lags, FPE suggested three lags, while AIC and HQ suggested four lags. Therefore, the study chooses four lags based on AIC and HQ.

Table 4.14: Lag Selection Criteria

Endogenous variables: LFUT, LADOP, LRGDP, LHLTH, LEDF

Lag	LR	FPE	AIC	SC	HQ
0	NA	1.10e-07	-1.829517	-1.598229	-1.754123
1	208.3635*	1.36e-10	-8.551153	-7.163423*	-8.098787
2	30.29912	1.72e-10	-8.453205	-5.909034	-7.623869
3	34.87914	1.25e-10*	-9.165578	-5.464966	-7.959271
4	21.67211	1.80e-10	-9.719886*	-4.862833	-8.136608*

Source: Author's Computation. Note: indicates lag order selected by the criterion, LR: Sequential modified LR test statistics (each at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: schwarz information criterion, HQ: Hannan-Quinn information criterion*

(ii) Long-run Analysis – ARDL Bound Test for Cointegration

The model testing the existence or otherwise of long-run relationships among the variables using the ARDL bounds testing approach is presented in Table 4.15.

Table 4.15: ARDL Long-Run (Cointegration) Estimates

Dependent Variable: D(LFUT)

Variable	**Coefficient**	**Prob.**
C	-1.330123	0.4036
D(LFUT(-1))	-0.944523	0.0276
D(LFUT(-2))	-0.544415	0.1563
D(LFUT(-3))	0.169760	0.4447
D(LADOP(-1))	-0.016628	0.0240

D(LADOP(-2))	-0.006572	0.1218
D(LRGDP(-1))	-0.044347	0.1956
D(LRGDP(-2))	0.059450	0.0495
D(LRGDP(-3))	0.028200	0.3669
D(LHLTH(-1))	-0.001482	0.6335
D(LHLTH(-2))	0.002062	0.2455
D(LEDF(-1))	0.004978	0.1730
D(LEDF(-3))	0.001666	0.2459
LFUT(-1)	0.243078	0.4253
LADOP(-1)	0.024109	0.0052
LRGDP(-1)	0.034306	0.2455
LEDF(-1)	-0.006562	0.0477
R-squared	0.759147	
F-statistic	2.757924	0.031579
D-W stat 2.636595		

Source: Author's Computation using Eviews 8

The result of the bound test for cointegration presented in table 4.16 shows that the bounds F-statistics value of 4.877653 is greater than the critical upper bound F-statistics valueof 4.35 at K = 3 and at 5% level of significance. We thereforeconclude that the variables are cointegrated.

Table 4.16: Bounds Test for Cointegration

Test Statistic	**Value**	**Prob.**
F-statistic	4.877653	0.0113
Chi-square	19.51061	0.0006
t-statistic	0.821161	0.4253
Chi-square	0.674306	0.4116

Asymptotic critical value bounds: Case III: Unrestricted intercept and no trend

	0.10		0.05		0.01	
K = 3	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
F- Statistics	2.72	3.77	3.23	4.35	4.29	5.61
t- Statistics	-2.57	-3.46	-2.86	-3.78	-3.43	-4.37

Source: Pesaran et al (2001), p.300 – 303

Derived from Table 4.15, the equation showing the long-run relationships is presented in equation 4.3.

$$LFUT_t = -1.3301 + 0.024LADOP_{t-1} + 0.034LRGDP_{t-1} - 0.007LEDF_{t-1} \ldots\ldots\ldots \quad 4.3$$
$$(\qquad (0.4036) \quad (0.0052) \quad (0.2455) \quad (0.0477)$$

Equa

under-five children who are affected by anaemia in Nigeria in the long run even at 1% level of significance. Notably, a percentage increase inADOPwill raise the number of the anaemic under-five children by about 2.4% in the longrun. This signifies that, in the long run, increasing ADOP will have a negative effect on food utilization since the metric increases with increases in ADOP. This finding is partially consistent with Abdullateef and Ijaiya (2010) as they identified long-run negative impact of trade openness on food utilization. The positive but insignificant impact of RGDP on LFUT is also worthy of note. This implies that if the current trend of RGDP continues without appreciable improvement, percentage of anaemic under-five children will be increasing, albeit marginally. Notably, EDF may improve food utilization in the long run as it exhibits a negative and significant relationship with the FUT metric.

(iii) Short-run Analysis – The Error Correction Model

Resulting from the Hendry's general-to-specific procedure, the parsimonious ECM obtained from the general ECM presented in appendix 3.3a is presented in Table 4.17.

Since the ECT in Table 4.17 is statistically significant at 5%, the coefficient indicates that the short-run disequilibrium adjusts to equilibrium in the long-run equilibrium at a speed of about 33.9%. The result also shows that a percentage increase in ADOP in the past 2 years will cause percentage of anaemic under-five children in the current year to increase by about 0.5%. This implies that the ADOP in the current year will have negative effect on food utilization in the next two years. This finding is consistent with Abdullateef and Ijaiya (2010) that trade degree of openness has negative impact on food utilization even in the short run.

Aside the joint significance of the independent variables as indicated by the probability value of F-statistics (0.027687), the D-W statistics indicates the absence of autocorrelation in the model. More so, the other diagnostics indicate the absence of serial correlation, hetero-skedasticity and specification errors, and that the residuals of the model arenormally distributed according to the Jarque-Bera normality test.Finally, CUSUM test of parameter instabilityreveals satisfactory plot of the recursive residuals at 5% level of significance. In addition, the CUSUMSQ test does not exhibit any sign of structural break. This goes a long way to reinforcing the validity of the model.

Table 4.17: Parsimonious Error Correction Model

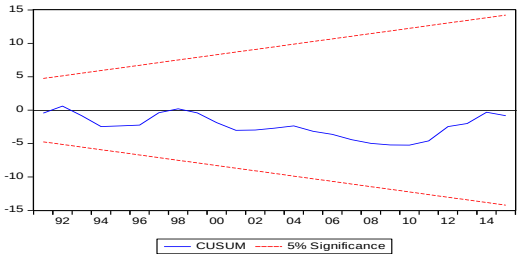
Dependent Variable: D(LFUT)

VariableCoefficient	**Prob.**	
C	0.000860	0.6010
D(LFUT(-2))	0.345497	0.0939
D(LFUT(-3))	0.529110	0.0101
D(LADOP(-2))	0.004767	0.0718
D(LRGDP(-2))	0.032782	0.2661
D(LHLTH(-1))	-0.002154	0.0477

ECT(-1)	-0.338918	0.0331
R-squared	0.502074	
F-statistic	2.772909	0.027687
D-W stat	2.021681	
Serial Correlation LM Test		
F-statistic	0.124559	0.8836
Obs*R-squared	0.38138	0.8264
Heteroskedasticity Test: ARCH		
F-statistic	0.639366	0.7366
Obs*R-squared	5.847801	0.6643
Normality Test		
Jarque-Bera	1.514550	0.468943
Specification Error (Ramsey RESET) Test		
F-statistic	2.107892	0.1613

Source: Author's Computation using Eviews 8

Parameter Stability Tests



It is therefore concluded that there exists a negative and significant impact of ADOP on food utilization both in the short run and the long run as ADOP varies positively with changes in the percentage of under-five children affected by anaemia in both time frames.

4.3.3 Error Correction Model (ECM)-Causality on Model Three {Recall: $FUT = f(ADOP, RGDP, HLTH, EDF)$}

Similar to the results in Table 4.13, there is a unidirectional causality running from ADOP to food utilization proxied by the percentage of under-five children affected by anaemia. This is shown in Table 4.18. The coefficient of ADOP which is significant at 5% level shows that a 1% increase in ADOP in a year will increase FUT in the following year by about 0.5%. The 33.9% short-run to long-run speed of adjustment signified by the

coefficient of the ECT is plausible as it is significant at signifies that the short-run processes adjust to a long-run equilibrium at a speed of about 33.9%.

Table 4.18: Causality Test Based on Error Correction Model between Agricultural Degree of Openness and Food Utilization in Nigeria
Equation: DLADOP 'cause' DLFUT

Dependent Variable: *DLFUT*			**Dependent Variable: *DLADOP***		
Variables	**Coefficient**	**t-statistic**	**Variables**	**Coefficient**	**t-statistic**
C	0.000860	0.530580	***C***	-0.027504	-0.420068
D(LFUT(-3))	0.529110	2.815636**	***D(LFUT(-1))***	12.90925	1.175864
D(LADOP(-1))	0.004982	2.173015**	***D(LHLTH(-2))***	0.165571	2.206103**
D(LHLTH(-1))	-0.002154	-2.096727**	***ECT(-1)***	-0.627324	-3.522688*
ECT(-1)	-0.338918	-2.274217**			
DW: 2.021681			***DW:*** 1.904151		

Source: Author's Computation

Note: * and ** depict significance at 1% and 5% levels respectively

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of the Study

The study examined the impact of agricultural trade intensity proxied by ADOP on the three dimensions of food security in Nigeria, namely food availability, food access and food utilization; using time series data for the period 1981-2015. Therefore, three models that reflect the different dimensions were estimated. The stationarityproperties of the variables were tested to avoid spurious regression results. This was done with the Augmented Dickey Fuller (ADF) andPhillips Perron (PP) unit root tests. It was found that the variables are a mixture of I(0) and I(1). So, to determine the long-run relationships and short-run dynamic interactions between the variables, the study used ARDL bound test approach to

cointegration.Relying on the parsimonious error correction models, the ECM-causality framework was carried out to further investigate the causal link between ADOP and the three dimensions of food security in Nigeria. The results indicated that in the long run, ADOP is positively and significantly related to all the three measures of food security. In the short run, ADOP is negatively related to FAV and FAC measures. But the former relationship is insignificant, while the latter is significant. On the other hand, ADOP positively and significantly interacts with the FUT measure in the short run. It is pertinent to note that the proxies used for the three dimensions of food security are negative in nature. Therefore, positive relationships imply negative impact on food security and vice versa. That is, ADOP would significantly worsen food security in Nigeria in the long run.Similarly, in the short run, ADOP improves food availability and food access, while it significantly worsens food utilization.

5.2 Conclusion

The study concludes that in the long run agricultural trade liberalization negatively affects food security in Nigeria as agricultural degree of openness exhibits long-run negative relationships with food availability, food access and food utilization. This stemmed from Nigeria's undue reliance on agricultural trade and failure to appreciate the multi-dimensional and general-equilibrium nature of food security, thereby leaving the country food insecure.This problem may persist if the current trajectory of food production, storage and processing and other elements of sustainable food system does not improve. Recent trends have shown that the short-run positive but insignificant impact of agricultural trade liberalization on food security leaves the country vulnerable to unfavourable external shocks. This is an indication that it is

not sustainable for the country to rely on food imports. More so, the significant and negative impact of ADOP on food utilization in the short run indicates that the nutritional quality and safety of food imports are questionable as the country's nutrition-related health condition has worsened over the years.

5.3 Recommendations

The following policy recommendations follow from the findings of the studythat would be applicable to the Nigerian economy given the trajectory of agricultural trade liberalizationand how it affects all the dimensions of food security in Nigeria.

It is pertinent to note that the concept of 'advantage' is common to all the trade theories. This points to the reality that countries are not engaged in agricultural trade to essentially help other countries but to maximize the benefits therefrom. This implies that Nigeria should strive to feed herself largely from within and export food items for foreign exchange earnings. To this end, the stakeholders should be made to understand, via the orientation agencies, that food security means national security in all ramifications – economic, socio-political and otherwise.

Though it has been found that agricultural trade liberalization is not sustainable for food security, Nigeria cannot afford to embark on undue restrictive trade policies as these can only worsen the problem by raising the prices of smuggled food items. It is therefore recommended that Nigeria's quest for reduced agricultural trade openness should be pursued simultaneously with the drive for self-sufficiency in food supply.

Specifically, the negative ADOP-food availability nexus requires an overhaul of the entire Sustainable Food System (SFS) in terms of sustainable food production, processing and storage; infrastructure, institutions and processes in a bid to enhance food security in Nigeria. As a component of sustainable food production, the vast arable land should be equipped with irrigation facilities to complement the dwindling rainfall in the face of climate change.

Furthermore, agricultural credit should be stepped up for active and prospective participants in the agricultural value chain and this should be complemented with capacity building. A fair selection of the participants can even be sponsored to understudy some successful farmers or farming institutions abroad. Those engaged in farming should be provided with requisite inputs like agro-chemicals, improved seedlings, as well as up-to-date extension services.

The harmful effect of agricultural trade openness on food utilization both in the short run andin the long run makes the safety and quality of domestically produced and imported food a relevant issue. The safety and quality standards of imported food items should be reviewed. The agencies concerned with setting and monitoring the standards should be better funded for better staff training and technology acquisition.

Finally, the observed impact of some control variables suggests that trade policies do not operate in isolation. So, Nigeria's food security concern should be factored into macroeconomic policy formulation and implementation because the product, factor and financial markets are inter-linked.

5.4 Suggestions for Further Study

This study has established negative impact of agricultural trade liberalization on various dimensions of food security in Nigeria. However, some limitations provide impetus on suggestions for further research.

(i) The nexus should further be investigated at sub-national levels such as geopolitical zones, states and local government areas to throw closer light on the nexus at such levels. This will in turn provide insightful information for policy formulation and implementation at such levels;

(ii) The relationships can also be investigated based on particular traded agricultural products which could be inputs or outputs in order to evaluate the contributions of specific products to food security in Nigeria;

(iii) An investigation can also be carried out on the impact of specific trade policy measures on food security instead of the general indicator of agricultural trade policy utilized in this study; and

(iv) Studies on food security can also be carried out with respect to particular trade regimes in order to facilitate informed comparison between regimes.

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APPENDICES

APPENDIX I:

SUMMARY OF EMPIRICAL STUDIES AND DATA ISSUES

Table 1.1: Summary of Empirical Studies

S/N	STUDY	COUNTRY/ REGION	METHODOLOGY	FOOD SECURITY METRIC	TRADE POLICY METRIC	IMPACT

1.	Huang et al. (1999)	China	Ex-ante simulation	Grain self-sufficiency,grainconsumption	Tariffs, exportsubsidies, tradebarriers reduced	+ve/-ve
2.	Shapouri, S. and Trueblood, M. (2001)	Low-income countries	econometrics	Food Gaps	Removal of domesticsupport. Impact of rising food prices, and of full ATL	+ve
3.	Meijl and van Tongeren (2001)	Some Asian countries	Ex-ante simulation	Food access, purchasing power forprimary food products	Tariffs reduction	+ve
4.	Jayne and Mckaay (2001)	Kenya	Cointegration and causality	Grains Price Chnges	Border measures	+ve
5.	Madeley and Solagral (2001)	India	CGE	Per capita calorie intake	Domestic support removal and rising food prices	+ve/-ve
6.	Chen and Duncan (2008)	China	CGE: Ex-ante	Self-sufficiency	Tariff Reduction	-ve
7.	Usman and Ijaiya (2010). Agricultural trade liberalization and foodsecurity in Nigeria	Nigeria	CGE	Total quantity of food requirement, food utilisation	End of export duties	-ve
8.	Bezuneh and Yiheyis (2012)	African countries	econometrics	Bonilla Index	Subsidy removal and tariffication	-ve
9.	Salvatici et al (2014)	Developing countries	non-parametric matching technique: Generalised Propensity Score (GPS)	Per capita daily dietary energy supply	Doha Round (elimination o protection andsubsidies)	+ve/-ve
10.	Panda, M. and Ganesh-Kumar, A. (2009). *Trade liberalization, poverty, and foodsecurity in India;* IFPRI Discussion Paper 00930	India	CGE	Per capita calorie intake	Tariff reduction (unilateral and multilateral)	+ve/-ve
11.	Chand, R. and Praduman, K. (2006). *Trade-related reforms and food security:country case studies* (Thomas H, ed.): 329-364	India	econometrics	Calorieintake, poverty	Exchange rate devaluation, improvementintrade terms	+ve/-ve
12.	Chowdhury, N., Farid N., Roy, D. (2006). Food policy liberalization in Bangladesh: how the government and the markets delivered?	Bangladesh	CGE	Foodconsumption, caloric intake	Tariff reduction	+ve/-ve
13.	Oyejide, T. A., Ogunkola E O. and Alaba, O. B. (2006) Nigeria. In: Thomas, H. (ed. Trade-related reforms and food security: country case studies. Rome: Food and Agriculture Organization o the United Nations, page	Nigeria	Trend Analysis	Undernourished, calorie intake, import dependence	Reduced import tariffs	+ve

	465–501.					
14.	Thomas, C. Y. and Bynoe, M. (2006)	Guyana	econometrics	Calorie intake, undernourished, poverty	Removal of quotas licenses	+ve
15.	Bezuneh, M., Yiheyis, Z. (2009). Has trade liberalization improved food availability in developing countries? An empirical analysis	Developing countries	Econometric	Per capita daily dietary energy supply	Subsidy removal and tariff reduction	-ve
16.	Chang M., Sumner D. A. (2004). Trade impact on food security: analysis on farm households in rural China	China	Econometric/ ex-ante	Household rice consumption	Border liberalization	+ve
17.	Chirwa E. W., Zakeyo C. (2006). Malawi: Trade-related reforms and food security: country case studies (Thomas H, ed.): 399-433	Malawi	Before/after	Nutritional status	Removal of trade barriers, price liberalization	+ve/-ve
18.	Diao, X. S., Diaz-Bonilla, E., Robinson, S., Orden, D. (2005). Tell me where it hurts an' I'll tell you who to call: industrialized countries' agricultural policies and developing countries; IFPRI Discussion Paper	Global	CGE: ex-ante	Agricultural consumption	Doha Round (elimination of protection andsubsidies)	+ve/-ve

Table 1.2: Definition of Variables, Notations and Sources of Data

S/N	Notation	Description/measurement	Source
1.	FAV	Food availability proxied by per capita food supply variability (kcal/capita/day)	FAOSTAT
2.	FAC	Food access proxied by number of the undernourished in millions	FAOSTAT
3.	FUT	Food utilization proxied by prevalence of anemia among children under 5 years of age (%)	FAOSTAT

4.	ADOP	Sum of agric. exports and imports divided by agriculture share Nigeria's GDP	NBS, CBN, WITS
5.	AFN	Agric. Sector Expenditure	CBN, NBS
6.	AL	Percentage of arable land irrigated	WDI
7.	RNF	Annual rainfall	NBS, FMARD
8.	EXCH	The product of nominal exchange rate (the dollar cost of a Naira) and the ratio of prices between Nigeria and the US.	CBN
9.	CPI	Average aggregate domestic price index of consumer goods.	CBN
10.	ACR	Loans given to farmers	CBN, FMARD
11.	HLTH	Health Sector Expenditure	FMF, CBN
12.	RGDP	Real gross domestic product	NBS, CBN
13.	RDS	Road density per 100 square kilometers of total land area	FAOSTAT
14.	EDF	Education Sector Expenditure	FAOSTAT

Source: Author's Compilation

APPENDIX II: UNIT ROOT TESTS RESULTS

Table 2.1:ADF Unit Root Test

Level					**First diff**				**Rmk**
Variable	**ADF Stat**	**1%**	**5%**	**10%**	**ADF Stat**	**1%**	**5%**	**10%**	
LACR	-2.2964	-4.2529	-3.5485	-3.2071	-5.7129	-4.2627*	-3.5530	-3.2096	I(1)
LADOP	-4.0110	-4.2529	-3.549*	-3.2071	-8.7828	-4.2627	-3.5529	-3.2096	I(0)
LAFN	-2.3405	-4.2529	3.5485	-3.2071	-6.5201	-4.2733	-3.5578	-3.2124	I(1)
LAL	-2.6437	-4.2529	-3.5485	-3.2071	-5.6636	-4.2627	-3.5530	-3.2096	I(1)
LCPI	-1.5289	-4.2529	-3.5485	-3.2071	-4.9301	-4.2627	-3.5530	-3.2096	I(1)
LEDF	-3.4983	-4.2529	-3.5485	-3.2071*	-5.4498	-4.2967	-3.5684	3.2184	I(0)
LEXCH	-1.0395	-4.2529	-3.5485	-3.2071	-5.3956	-4.2627*	-3.553	-3.2096	I(1)
LFAC	-0.9449	-4.2529	-3.5485	-3.2071	-4.2829	-4.2627*	-3.553	-3.2096	I(1)
LFAV	-3.9577	-4.2733	-3.5578	-3.2124	-5.6043	-4.2627	-3.553*	-3.2096	I(1)
LFUT	-1.7748	-4.2627	-3.553	-3.2096	-6.9857	-4.263*	-3.553	-3.2096	I(1)
LHLTH	-0.6699	-4.2967	-3.5684	-3.2184	-5.1852	-4.2967*	-3.5684	-3.2184	I(1)
LRDS	-1.9096	-4.2732	-3.5578	-3.2124	-2.574	-4.2846	-3.5629	-3.2153	I(2)
LRGDP	-2.2194	-4.2627	-3.553	-3.2096	-3.603	-4.2627	-3.553*	-3.2096	I(1)
LRNF	-3.8244	-4.2529	-3.549*	-3.2071	-8.7836	-4.2627	-3.553	-3.2096	I(0)

Source: Author's Computation using Eviews 8

*Note: *, ** and *** indicate statistical significance at 1%, 5% and 10% levels respectively. The null hypothesis of unit root is rejected if ADF statistic <ADF critical value. The ADF critical values are Mackinnon (1996) one-sided p-values.*

Table 2.2: Phillips-Perron (PP) Unit Root Test

Level					First diff				Remark
Variables	**PP Stat**	**1%**	**5%**	**10%**	**PP Stat**	**1%**	**5%**	**10%**	
LACR	-2.3385	-4.2529	-3.5485	-3.2071	-5.7328	-4.263*	-3.5529	-3.2096	I(1)
LADOP	-4.0390	-4.2529	-3.549*	-3.2071	-9.6097	-4.2627	-3.5530	-3.2096	I(0)
LAFN	-2.1698	-4.2529	-3.5485	-3.2071	-13.848	-4.263*	-3.5530	-3.2096	I(1)
LAL	-2.7203	-4.2529	-3.5485	-3.2071	-5.7728	-4.263*	-3.5530	-3.2096	I(1)
LCPI	-1.4786	-4.2529	-3.5485	-3.2071	-5.0182	-4.263*	-3.5530	-3.2096	I(1)
LEDF	-3.4418	-4.2529	-3.5485	-3.207*	-9.6681	-4.2627	-3.5530	-3.2096	I(0)
LEXCH	-1.0212	-4.2529	-3.5485	-3.2071	-5.8684	-4.263*	-3.5530	-3.2096	I(1)
LFAC	-1.4285	-4.2529	-3.5485	-3.2071	-4.2829	-4.263*	-3.5530	-3.2096	I(1)
LFAV	-2.1239	-4.2529	-3.5485	-3.2071	-9.9714	-4.263*	-3.5530	-3.2096	I(1)
LFUT	-1.7072	-4.2529	-3.5485	-3.2071	-6.8866	-4.263*	-3.5530	-3.2096	I(1)
LHLTH	-4.5034	-4.2529	-3.5485	-3.2071	-17.691	-4.263*	-3.5530	-3.2096	I(1)
LRDS	-0.8775	-4.2529	-3.5485	-3.2071	-3.9670	-4.2627	-3.553*	-3.2096	I(1)
LRGDP	-2.3113	-4.2529	-3.5485	-3.2071	-3.4627	-4.2627	-3.5530	-3.209*	I(1)
LRNF	-3.8823	-4.2529	-3.5485	-3.2071	-11.275	-4.263*	-3.5530	-3.2096	I(1)

Source: Author's Computation using Eviews 8

*Note: *, ** and *** indicate statistical significance at 1%, 5% and 10% levels respectively. The null hypothesis of unit root is rejected if PP statistic < PP critical value. The PP critical values are Mackinnon (1996) one-sided p-values.*

APPENDIX III

BOUND-TESTING (ARDL) COINTEGRATION RESULTS

Appendix 3.1a: Impact of ADOP on Food Availability in Nigeria

Lag Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: LFAV LADOP LRGDP LAFN LAL LRNF
Exogenous variables: C
Date: 08/04/16 Time: 21:18
Sample: 1981 2015
Included observations: 31

Lag	LogL	LR	FPE	AIC	SC	HQ

0	-16.59693	NA	1.73e-07	1.457866	1.735412	1.548339
1	122.3978	215.2177	2.36e-10	-5.186958	-3.244136	-4.553646
2	153.8210	36.49137	4.21e-10	-4.891675	-1.283579	-3.715526
3	201.1648	36.65328	4.87e-10	-5.623535	-0.350162	-3.904547
4	360.6803	61.74794*	2.09e-12*	-13.59228*	-6.653630*	-11.33045*

* 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

Long-Run (Unrestricted) Relationships

Dependent Variable: D(LFAV)
Method: Least Squares
Date: 08/04/16 Time: 21:58
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	96.68969	25.26547	3.826949	0.0021
D(LFAV(-2))	0.135940	0.214465	0.633858	0.5372
D(LADOP(-1))	-1.383978	0.366719	-3.773950	0.0023
D(LADOP(-2))	-0.346943	0.265570	-1.306409	0.2141
D(LRGDP(-1))	2.575283	2.922716	0.881127	0.3942
D(LRGDP(-3))	5.976006	2.504987	2.385644	0.0330
D(LAFN(-1))	0.202642	0.122021	1.660712	0.1207
D(LAFN(-2))	0.140392	0.137068	1.024249	0.3244
D(LAFN(-3))	0.307881	0.138515	2.222731	0.0446
D(LAL(-3))	6.040063	2.014847	2.997778	0.0103
D(LRNF(-1))	8.474934	2.303204	3.679627	0.0028
D(LRNF(-2))	7.184286	1.822035	3.943002	0.0017
D(LRNF(-3))	4.000700	1.676494	2.386350	0.0329
LFAV(-1)	-0.276476	0.211117	-1.309585	0.2130
LADOP(-1)	1.974303	0.476867	4.140157	0.0012
LRGDP(-1)	1.231809	0.464093	2.654227	0.0199
LAL(-1)	-3.115150	1.361730	-2.287642	0.0396
LRNF(-1)	-9.562693	2.599210	-3.679077	0.0028

R-squared	0.743330	Mean dependent var	-0.007935
Adjusted R-squared	0.407684	S.D. dependent var	0.503380
S.E. of regression	0.387412	Akaike info criterion	1.233595
Sum squared resid	1.951142	Schwarz criterion	2.066233
Log likelihood	-1.120726	Hannan-Quinn criter.	1.505014
F-statistic	2.214624	Durbin-Watson stat	1.791260
Prob(F-statistic)	0.075780		

Source: Author's Computation

Coefficient Diagnosis for Bounds

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	4.558262	(5, 13)	0.0127
Chi-square	22.79131	5	0.0004

Null Hypothesis: C(14)=C(15)=C(16)=C(17)=C(18)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(14)	-0.276476	0.211117
C(15)	1.974303	0.476867
C(16)	1.231809	0.464093
C(17)	-3.115150	1.361730
C(18)	-9.562693	2.599210

Restrictions are linear in coefficients.

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	-1.309585	13	0.2130
F-statistic	1.715013	(1, 13)	0.2130
Chi-square	1.715013	1	0.1903

Null Hypothesis: C(14)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(14)	-0.276476	0.211117

Restrictions are linear in coefficients.

General Error Correction Model (Short-Run Relationships)

Dependent Variable: D(LFAV)
Method: Least Squares
Date: 08/17/16 Time: 00:39
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.006499	0.271066	-0.023977	0.9812
D(LFAV(-2))	0.026704	0.273155	0.097760	0.9233
D(LADOP(-1))	-0.234675	0.331026	-0.708933	0.4880
D(LADOP(-2))	0.140879	0.315767	0.446149	0.6611
D(LRGDP(-1))	-1.047418	3.431118	-0.305270	0.7639
D(LRGDP(-3))	0.301734	2.592982	0.116366	0.9087
D(LAFN(-1))	0.135722	0.158561	0.855958	0.4039
D(LAFN(-2))	-0.059642	0.184126	-0.323922	0.7499
D(LAFN(-3))	0.040418	0.164142	0.246237	0.8084
D(LAL(-3))	1.999625	2.056464	0.972361	0.3445
D(LRNF(-1))	0.291981	2.134768	0.136774	0.8928
D(LRNF(-2))	1.129595	2.000023	0.564791	0.5796
D(LRNF(-3))	0.347648	1.924443	0.180649	0.8588
ECT(-1)	-0.392774	0.322407	-1.218254	0.2398

R-squared	0.350080	Mean dependent var	-0.007935
Adjusted R-squared	-0.146917	S.D. dependent var	0.503380
S.E. of regression	0.539091	Akaike info criterion	1.904587
Sum squared resid	4.940522	Schwarz criterion	2.552194

Log likelihood	-15.52109	Hannan-Quinn criter.	2.115690
F-statistic	0.704391	Durbin-Watson stat	1.554599
Prob(F-statistic)	0.736085		

Source: Author's Computation

Parsimonious Error Correction Model (Short-Run Relationships)

Dependent Variable: D(LFAV)
Method: Least Squares
Date: 08/17/16 Time: 00:50
Sample (adjusted): 1983 2015
Included observations: 33 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.018565	0.075855	-0.244744	0.8083
D(LADOP(-1))	-0.234791	0.184057	-1.275640	0.2119
ECT(-1)	-0.479998	0.169570	-2.830669	0.0082

R-squared	0.252444	Mean dependent var	-0.007445
Adjusted R-squared	0.202607	S.D. dependent var	0.487401
S.E. of regression	0.435233	Akaike info criterion	1.260640
Sum squared resid	5.682846	Schwarz criterion	1.396686
Log likelihood	-17.80056	Hannan-Quinn criter.	1.306415
F-statistic	5.065399	Durbin-Watson stat	1.694240
Prob(F-statistic)	0.012725		

Source: Author's Computation

Diagnostic Tests

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.966996	Prob. F(2,28)	0.3926
Obs*R-squared	2.132082	Prob. Chi-Square(2)	0.3444

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 08/17/16 Time: 00:53
Sample: 1983 2015
Included observations: 33
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.000224	0.076033	-0.002947	0.9977
D(LADOP(-1))	0.201184	0.270113	0.744814	0.4626
ECT(-1)	-0.415770	0.432323	-0.961711	0.3444
RESID(-1)	0.527087	0.424107	1.242817	0.2242
RESID(-2)	0.106585	0.299737	0.355596	0.7248

R-squared	0.064609	Mean dependent var	0.000000
Adjusted R-squared	-0.069019	S.D. dependent var	0.421413
S.E. of regression	0.435713	Akaike info criterion	1.315062
Sum squared resid	5.315685	Schwarz criterion	1.541805
Log likelihood	-16.69852	Hannan-Quinn criter.	1.391354
F-statistic	0.483498	Durbin-Watson stat	2.147360
Prob(F-statistic)	0.747641		

Source: Author's Computation

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.609778	Prob. F(2,30)	0.5501
Obs*R-squared	1.289108	Prob. Chi-Square(2)	0.5249
Scaled explained SS	2.630179	Prob. Chi-Square(2)	0.2685

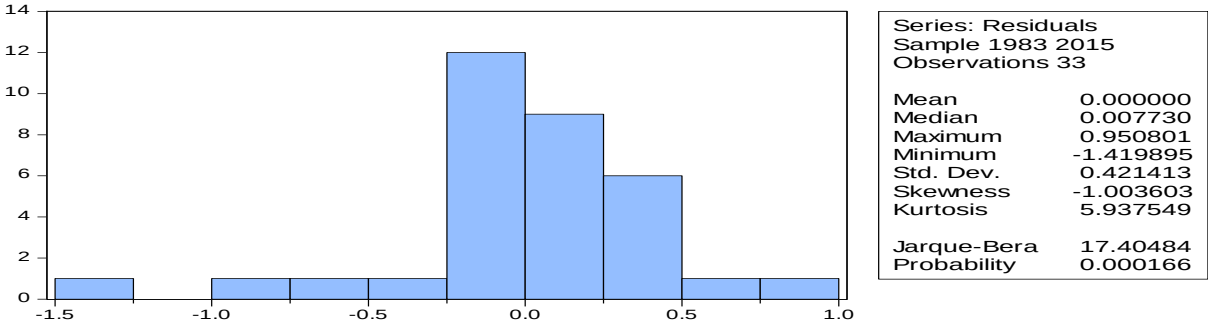
Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 08/17/16 Time: 00:54
Sample: 1983 2015
Included observations: 33

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.169165	0.068567	2.467150	0.0195
D(LADOP(-1))	-0.115015	0.166373	-0.691309	0.4947
ECT(-1)	-0.125122	0.153278	-0.816308	0.4208

R-squared	0.039064	Mean dependent var	0.172207
Adjusted R-squared	-0.024999	S.D. dependent var	0.388588
S.E. of regression	0.393415	Akaike info criterion	1.058606
Sum squared resid	4.643268	Schwarz criterion	1.194652
Log likelihood	-14.46700	Hannan-Quinn criter.	1.104381
F-statistic	0.609778	Durbin-Watson stat	2.155328
Prob(F-statistic)	0.550070		

Source: Author's Computation

Residual Normality Test



Ramsey RESET Test
Equation: UNTITLED
Specification: D(LFAV) C D(LADOP(-1)) ECT(-1)
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	2.008636	29	0.0540
F-statistic	4.034619	(1, 29)	0.0540
Likelihood ratio	4.298588	1	0.0381

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.694063	1	0.694063
Restricted SSR	5.682846	30	0.189428

Unrestricted SSR	4.988782	29	0.172027
Unrestricted SSR	4.988782	29	0.172027

LR test summary:

	Value	df
Restricted LogL	-17.80056	30
Unrestricted LogL	-15.65126	29

Unrestricted Test Equation:
Dependent Variable: D(LFAV)
Method: Least Squares
Date: 08/17/16 Time: 00:56
Sample: 1983 2015
Included observations: 33

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.104124	0.083904	-1.240996	0.2246
D(LADOP(-1))	-0.248414	0.175531	-1.415216	0.1677
ECT(-1)	-0.395698	0.166955	-2.370080	0.0247
FITTED^2	1.500891	0.747219	2.008636	0.0540

R-squared	0.343746	Mean dependent var	-0.007445
Adjusted R-squared	0.275857	S.D. dependent var	0.487401
S.E. of regression	0.414761	Akaike info criterion	1.190986
Sum squared resid	4.988782	Schwarz criterion	1.372380
Log likelihood	-15.65126	Hannan-Quinn criter.	1.252019
F-statistic	5.063396	Durbin-Watson stat	1.610161
Prob(F-statistic)	0.006088		

Appendix 3.1b: Impact of FAV on ADOP

Long-Run (Unrestricted) Cointegration Results

Dependent Variable: D(LADOP)
Method: Least Squares
Date: 08/17/16 Time: 01:05
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-69.96352	61.47258	-1.138126	0.2985
D(LADOP(-1))	-0.860525	1.436871	-0.598888	0.5712
D(LADOP(-2))	-0.825974	0.768472	-1.074827	0.3238
D(LADOP(-3))	-0.371077	0.335879	-1.104795	0.3116

D(LFAV(-1))	-0.566294	1.385181	-0.408823	0.6969
D(LFAV(-2))	-0.499894	1.124085	-0.444712	0.6721
D(LFAV(-3))	-0.173367	0.699958	-0.247681	0.8126
D(LRGDP(-1))	-6.747683	3.554880	-1.898146	0.1064
D(LRGDP(-2))	-0.743081	3.943583	-0.188428	0.8568
D(LRGDP(-3))	0.495835	5.736556	0.086434	0.9339
D(LAFN(-1))	0.025884	0.272326	0.095050	0.9274
D(LAFN(-2))	-0.055067	0.242879	-0.226724	0.8282
D(LAFN(-3))	-0.051901	0.180547	-0.287466	0.7834
D(LAL(-1))	-2.228909	3.954262	-0.563673	0.5934
D(LAL(-2))	-1.873548	2.589697	-0.723462	0.4966
D(LAL(-3))	-0.541811	2.494325	-0.217218	0.8352
D(LRNF(-1))	-4.683417	4.960536	-0.944135	0.3815
D(LRNF(-2))	-0.500303	5.350498	-0.093506	0.9285
D(LRNF(-3))	-0.595122	2.523902	-0.235794	0.8214
LADOP(-1)	-0.587474	1.670609	-0.351653	0.7371
LFAV(-1)	0.180267	1.789894	0.100714	0.9231
LRGDP(-1)	0.187758	1.226720	0.153057	0.8834
LAFN(-1)	-0.088475	0.546164	-0.161993	0.8766
LAL(-1)	2.180347	4.571474	0.476946	0.6503
LRNF(-1)	6.110890	5.429016	1.125598	0.3033

R-squared	0.859649	Mean dependent var	0.007651
Adjusted R-squared	0.298246	S.D. dependent var	0.429505
S.E. of regression	0.359799	Akaike info criterion	0.764135
Sum squared resid	0.776733	Schwarz criterion	1.920576
Log likelihood	13.15591	Hannan-Quinn criter.	1.141106
F-statistic	1.531250	Durbin-Watson stat	2.012399
Prob(F-statistic)	0.312556		

Source: Author's Computation

Coefficient Diagnosis for Bounds

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	4.547035	(5, 13)	0.0129
Chi-square	22.73517	5	0.0004

Null Hypothesis: C(14)=C(15)=C(16)=C(17)=C(18)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(14)	-0.570851	0.270075
C(15)	0.443378	0.400694
C(16)	-0.163034	0.080061
C(17)	1.310245	1.052109
C(18)	5.729960	1.965373

Restrictions are linear in coefficients.

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	-2.113671	13	0.0544
F-statistic	4.467605	(1, 13)	0.0544
Chi-square	4.467605	1	0.0345

Null Hypothesis: C(14)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(14)	-0.570851	0.270075

Restrictions are linear in coefficients.

Long-Run (Restricted) Cointegration Results

Dependent Variable: D(LADOP)
Method: Least Squares
Date: 08/17/16 Time: 01:23
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-67.85692	20.65485	-3.285278	0.0059
D(LADOP(-1))	-0.791592	0.309662	-2.556310	0.0239
D(LADOP(-2))	-0.727617	0.278267	-2.614816	0.0214
D(LADOP(-3))	-0.352654	0.203194	-1.735553	0.1063
D(LFAV(-1))	-0.407935	0.114087	-3.575641	0.0034
D(LFAV(-2))	-0.359210	0.147444	-2.436254	0.0300
D(LRGDP(-1))	-6.471174	2.224672	-2.908822	0.0122
D(LAFN(-1))	0.077634	0.082373	0.942461	0.3631
D(LAL(-1))	-1.504704	1.517906	-0.991303	0.3396
D(LAL(-2))	-1.408719	1.323733	-1.064202	0.3066
D(LRNF(-1))	-4.392445	1.625348	-2.702464	0.0181
D(LRNF(-2))	-0.822899	1.366617	-0.602143	0.5574
D(LRNF(-3))	-0.956628	1.016788	-0.940833	0.3639
LADOP(-1)	-0.570851	0.270075	-2.113671	0.0544
LRGDP(-1)	0.443378	0.400694	1.106523	0.2886
LAFN(-1)	-0.163034	0.080061	-2.036371	0.0626
LAL(-1)	1.310245	1.052109	1.245352	0.2350
LRNF(-1)	5.729960	1.965373	2.915456	0.0120

R-squared	0.851639	Mean dependent var	0.007651
Adjusted R-squared	0.657629	S.D. dependent var	0.429505
S.E. of regression	0.251314	Akaike info criterion	0.368024
Sum squared resid	0.821063	Schwarz criterion	1.200662
Log likelihood	12.29562	Hannan-Quinn criter.	0.639444
F-statistic	4.389656	Durbin-Watson stat	2.186792
Prob(F-statistic)	0.004906		

Source: Author's Computation

General Error Correction Model (Short-Run Relationships)

Dependent Variable: D(LADOP)
Method: Least Squares
Date: 08/17/16 Time: 01:33
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.142748	0.147046	0.970769	0.3453
D(LADOP(-1))	-0.265079	0.356740	-0.743058	0.4676
D(LADOP(-2))	-0.098634	0.289685	-0.340488	0.7377

D(LADOP(-3))	0.156835	0.209178	0.749764	0.4636
D(LFAV(-1))	-0.302660	0.160509	-1.885619	0.0766
D(LFAV(-2))	0.042049	0.165583	0.253945	0.8026
D(LRGDP(-1))	-2.458864	2.272310	-1.082099	0.2943
D(LAFN(-1))	-0.068731	0.092546	-0.742674	0.4678
D(LAL(-1))	0.616793	1.480166	0.416705	0.6821
D(LAL(-2))	-0.459408	1.351565	-0.339908	0.7381
D(LRNF(-1))	-0.258997	1.369290	-0.189147	0.8522
D(LRNF(-2))	0.811902	1.227052	0.661669	0.5171
D(LRNF(-3))	-0.235919	1.141500	-0.206674	0.8387
ECT(-1)	-0.508613	0.353393	-1.439230	0.1682

R-squared	0.636471	Mean dependent var	0.007651
Adjusted R-squared	0.358479	S.D. dependent var	0.429505
S.E. of regression	0.344012	Akaike info criterion	1.006170
Sum squared resid	2.011850	Schwarz criterion	1.653778
Log likelihood	-1.595642	Hannan-Quinn criter.	1.217274
F-statistic	2.289525	Durbin-Watson stat	2.051728
Prob(F-statistic)	0.055524		

Source: Author's Computation

Parsimonious Error Correction Model (Short-Run Relationships)

Dependent Variable: D(LADOP)
Method: Least Squares
Date: 08/17/16 Time: 01:49
Sample (adjusted): 1984 2015
Included observations: 32 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.079784	0.088142	0.905174	0.3734
D(LFAV(-1))	-0.155806	0.117185	-1.329576	0.1948
D(LRGDP(-1))	-2.140401	1.490845	-1.435697	0.1626
D(LRNF(-2))	1.536723	0.708210	2.169868	0.0390
ECT(-1)	-0.794106	0.187118	-4.243882	0.0002

R-squared	0.531544	Mean dependent var	-0.002278
Adjusted R-squared	0.462143	S.D. dependent var	0.426237
S.E. of regression	0.312597	Akaike info criterion	0.654795
Sum squared resid	2.638350	Schwarz criterion	0.883816
Log likelihood	-5.476721	Hannan-Quinn criter.	0.730709
F-statistic	7.659046	Durbin-Watson stat	1.811693
Prob(F-statistic)	0.000293		

Source: Author's Computation

Diagnostic Tests

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.741267	Prob. F(2,25)	0.4867
Obs*R-squared	1.791411	Prob. Chi-Square(2)	0.4083

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 08/17/16 Time: 01:51
Sample: 1984 2015
Included observations: 32
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.023217	0.091608	0.253444	0.8020
D(LFAV(-1))	0.070983	0.133754	0.530699	0.6003
D(LRGDP(-1))	-0.338977	1.551684	-0.218458	0.8288
D(LRNF(-2))	-0.114232	0.729402	-0.156610	0.8768
ECT(-1)	-0.361791	0.379330	-0.953764	0.3493
RESID(-1)	0.395051	0.390393	1.011931	0.3213
RESID(-2)	0.241563	0.237520	1.017022	0.3189

R-squared	0.055982	Mean dependent var	2.60E-17
Adjusted R-squared	-0.170583	S.D. dependent var	0.291733
S.E. of regression	0.315636	Akaike info criterion	0.722185
Sum squared resid	2.490651	Schwarz criterion	1.042815
Log likelihood	-4.554967	Hannan-Quinn criter.	0.828465
F-statistic	0.247089	Durbin-Watson stat	1.958902
Prob(F-statistic)	0.955962		

Source: Author's Computation

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.436521	Prob. F(4,27)	0.7810
Obs*R-squared	1.943732	Prob. Chi-Square(4)	0.7461
Scaled explained SS	2.161438	Prob. Chi-Square(4)	0.7061

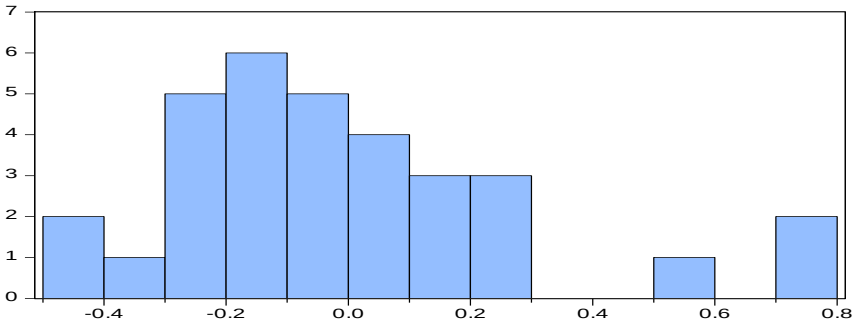
Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 08/17/16 Time: 01:52
Sample: 1984 2015
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.093153	0.043353	2.148686	0.0408
D(LFAV(-1))	-0.010869	0.057638	-0.188569	0.8518
D(LRGDP(-1))	-0.288635	0.733281	-0.393622	0.6970
D(LRNF(-2))	0.283525	0.348338	0.813936	0.4228
ECT(-1)	-0.081518	0.092035	-0.885724	0.3836

R-squared	0.060742	Mean dependent var	0.082448
Adjusted R-squared	-0.078408	S.D. dependent var	0.148058
S.E. of regression	0.153753	Akaike info criterion	-0.764343
Sum squared resid	0.638277	Schwarz criterion	-0.535321
Log likelihood	17.22948	Hannan-Quinn criter.	-0.688428
F-statistic	0.436521	Durbin-Watson stat	2.153129
Prob(F-statistic)	0.781039		

Source: Author's Computation

Residual Normality Tests



Series: Residuals
Sample 1984 2015
Observations 32

Mean	2.60e-17
Median	-0.046411
Maximum	0.797713
Minimum	-0.420009
Std. Dev.	0.291733
Skewness	1.126276
Kurtosis	4.123984
Jarque-Bera	8.449772
Probability	0.014627

Ramsey RESET Test
Equation: UNTITLED
Specification: D(LADOP) C D(LFAV(-1))D(LRGDP(-1)) D(LRNF(-2)) ECT(-1)
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.797527	26	0.4324
F-statistic	0.636049	(1, 26)	0.4324
Likelihood ratio	0.773408	1	0.3792

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.063002	1	0.063002
Restricted SSR	2.638350	27	0.097717
Unrestricted SSR	2.575349	26	0.099052
Unrestricted SSR	2.575349	26	0.099052

LR test summary:

	Value	df
Restricted LogL	-5.476721	27
Unrestricted LogL	-5.090017	26

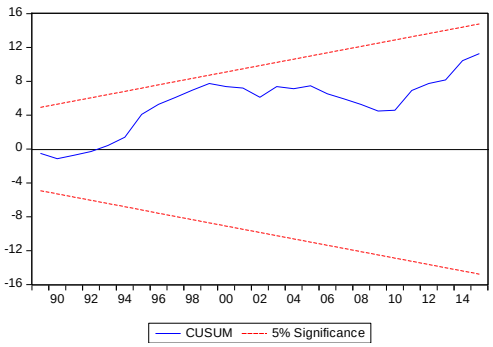
Unrestricted Test Equation:
Dependent Variable: D(LADOP)
Method: Least Squares
Date: 08/17/16 Time: 01:53
Sample: 1984 2015
Included observations: 32

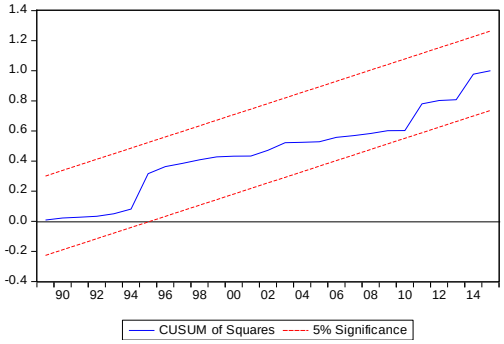
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.059694	0.092249	0.647104	0.5232
D(LFAV(-1))	-0.166709	0.118772	-1.403606	0.1723
D(LRGDP(-1))	-2.471963	1.557506	-1.587129	0.1246
D(LRNF(-2))	1.544814	0.713104	2.166322	0.0396
ECT(-1)	-0.887223	0.221639	-4.003017	0.0005
FITTED^2	0.372763	0.467399	0.797527	0.4324

R-squared	0.542731	Mean dependent var	-0.002278
Adjusted R-squared	0.454794	S.D. dependent var	0.426237
S.E. of regression	0.314725	Akaike info criterion	0.693126
Sum squared resid	2.575349	Schwarz criterion	0.967952
Log likelihood	-5.090017	Hannan-Quinn criter.	0.784223
F-statistic	6.171854	Durbin-Watson stat	1.894095
Prob(F-statistic)	0.000675		

Source: Author's Computation

Parameter Stability Tests





Appendix 3.2a: Impact of ADOP on Food Access

Lag Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: LFAC LADOP LEXCH LCPI LACR LRDS
Exogenous variables: C
Date: 08/17/16 Time: 02:01
Sample: 1981 2015
Included observations: 31

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-31.34417	NA	4.48e-07	2.409301	2.686847	2.499774
1	167.0526	307.1950	1.32e-11	-8.067909	-6.125088	-7.434598
2	197.3443	35.17749	2.54e-11	-7.699634	-4.091537	-6.523484
3	244.4138	36.44087	2.99e-11	-8.413792	-3.140420	-6.694804
4	383.6361	53.89252*	4.75e-13*	-15.07330*	-8.134650*	-12.81147*

* 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

Long-Run (Unrestricted) Cointegration Results

Dependent Variable: D(LFAC)
Method: Least Squares
Date: 08/17/16 Time: 02:06
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.353822	3.929361	1.617011	0.1570
D(LFAC(-1))	0.959768	0.855908	1.121346	0.3050
D(LFAC(-2))	0.397977	0.805703	0.493950	0.6389
D(LFAC(-3))	0.419498	0.690227	0.607769	0.5656
D(LADOP(-1))	-0.092835	0.192108	-0.483244	0.6461
D(LADOP(-2))	-0.028268	0.141924	-0.199180	0.8487
D(LADOP(-3))	-0.016639	0.084827	-0.196149	0.8510
D(LEXCH(-1))	-0.051163	0.075210	-0.680269	0.5217
D(LEXCH(-2))	-0.051554	0.066135	-0.779537	0.4653
D(LEXCH(-3))	-0.024722	0.070818	-0.349095	0.7389
D(LCPI(-1))	0.052335	0.757850	0.069057	0.9472
D(LCPI(-2))	-0.310913	0.767247	-0.405232	0.6994
D(LCPI(-3))	-0.173083	0.479356	-0.361073	0.7304
D(LACR(-1))	0.028899	0.105372	0.274252	0.7931

D(LACR(-2))	0.039767	0.082857	0.479950	0.6483
D(LACR(-3))	0.050465	0.050979	0.989921	0.3604
D(LRDS(-1))	1.668902	1.065427	1.566416	0.1683
D(LRDS(-2))	-0.376175	1.209529	-0.311009	0.7663
D(LRDS(-3))	0.268711	0.895368	0.300113	0.7742
LFAC(-1)	-1.054659	0.726907	-1.450886	0.1970
LADOP(-1)	0.106940	0.242788	0.440467	0.6750
LEXCH(-1)	0.022218	0.064905	0.342317	0.7438
LCPI(-1)	-0.171683	0.399809	-0.429413	0.6826
LACR(-1)	-0.030012	0.161508	-0.185823	0.8587
LRDS(-1)	-0.815667	0.793070	-1.028493	0.3434

R-squared	0.792649	Mean dependent var	-0.022045
Adjusted R-squared	-0.036757	S.D. dependent var	0.060346
S.E. of regression	0.061445	Akaike info criterion	-2.770685
Sum squared resid	0.022653	Schwarz criterion	-1.614244
Log likelihood	67.94562	Hannan-Quinn criter.	-2.393714
F-statistic	0.955682	Durbin-Watson stat	2.488834
Prob(F-statistic)	0.579139		

Source: Author's Computation

Bound Test for Cointegration

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	4.992597	(4, 16)	0.0083
Chi-square	19.97039	4	0.0005

Null Hypothesis: C(12)=C(13)=C(14)=C(15)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(12)	-0.762785	0.252261
C(13)	0.100984	0.033318
C(14)	-0.160188	0.075116
C(15)	-0.612315	0.157070

Restrictions are linear in coefficients.

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	-3.023793	16	0.0081
F-statistic	9.143327	(1, 16)	0.0081
Chi-square	9.143327	1	0.0025

Null Hypothesis: C(12)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(12)	-0.762785	0.252261

Restrictions are linear in coefficients.

Long-Run (Restricted) Cointegration Results

Dependent Variable: D(LFAC)
Method: Least Squares
Date: 08/17/16 Time: 02:30
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.595914	1.364969	3.367047	0.0039
D(LFAC(-1))	0.758541	0.253511	2.992136	0.0086
D(LFAC(-2))	0.160234	0.278855	0.574614	0.5735
D(LFAC(-3))	0.195342	0.240099	0.813590	0.4278
D(LADOP(-1))	-0.086628	0.026035	-3.327405	0.0043
D(LEXCH(-1))	-0.041750	0.029435	-1.418393	0.1753
D(LEXCH(-2))	-0.022397	0.029047	-0.771083	0.4519
D(LACR(-2))	0.015441	0.021261	0.726254	0.4782
D(LACR(-3))	0.035974	0.022198	1.620587	0.1246
D(LRDS(-1))	1.521679	0.373245	4.076890	0.0009
D(LRDS(-2))	-0.367695	0.368849	-0.996871	0.3337
LFAC(-1)	-0.762785	0.252261	-3.023793	0.0081
LADOP(-1)	0.100984	0.033318	3.030883	0.0080
LCPI(-1)	-0.160188	0.075116	-2.132526	0.0488
LRDS(-1)	-0.612315	0.157070	-3.898361	0.0013

R-squared	0.748249	Mean dependent var	-0.022045
Adjusted R-squared	0.527967	S.D. dependent var	0.060346
S.E. of regression	0.041460	Akaike info criterion	-3.221821
Sum squared resid	0.027503	Schwarz criterion	-2.527956
Log likelihood	64.93822	Hannan-Quinn criter.	-2.995638
F-statistic	3.396773	Durbin-Watson stat	2.391769
Prob(F-statistic)	0.010775		

Source: Author's Computation

Short-Run General Error Correction Model

Dependent Variable: D(LFAC)
Method: Least Squares
Date: 08/17/16 Time: 02:38
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.014202	0.014560	-0.975451	0.3416
D(LFAC(-1))	0.644406	0.192436	3.348676	0.0034
D(LFAC(-2))	0.060482	0.194405	0.311115	0.7591
D(LFAC(-3))	0.051746	0.198284	0.260971	0.7969
D(LADOP(-1))	-0.041689	0.022213	-1.876789	0.0760
D(LEXCH(-1))	-0.045871	0.027901	-1.644030	0.1166
D(LEXCH(-2))	-0.016893	0.028926	-0.583986	0.5661
D(LACR(-2))	0.023017	0.024059	0.956676	0.3507
D(LACR(-3))	0.019641	0.023324	0.842077	0.4102
D(LRDS(-1))	1.138579	0.353931	3.216952	0.0045
D(LRDS(-2))	-0.526330	0.322041	-1.634358	0.1186
ECT(-1)	-0.567892	0.170212	-3.336387	0.0035

R-squared	0.643114	Mean dependent var	-0.022045
Adjusted R-squared	0.436495	S.D. dependent var	0.060346
S.E. of regression	0.045300	Akaike info criterion	-3.066393
Sum squared resid	0.038989	Schwarz criterion	-2.511302

Log likelihood	59.52910	Hannan-Quinn criter.	-2.885447
F-statistic	3.112569	Durbin-Watson stat	1.945617
Prob(F-statistic)	0.014510		

Source: Author's Computation

Short-Run Parsimonious Error Correction Model

Dependent Variable: D(LFAC)
Method: Least Squares
Date: 08/17/16 Time: 02:47
Sample (adjusted): 1984 2015
Included observations: 32 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.009442	0.009842	-0.959364	0.3466
D(LFAC(-1))	0.549241	0.157263	3.492491	0.0018
D(LADOP(-1))	-0.040621	0.019280	-2.106874	0.0453
D(LEXCH(-1))	-0.042577	0.025423	-1.674746	0.1065
D(LRDS(-1))	0.898632	0.279514	3.214986	0.0036
D(LRDS(-2))	-0.640339	0.245947	-2.603569	0.0153
ECT(-1)	-0.463227	0.128242	-3.612137	0.0013

R-squared	0.593261	Mean dependent var	-0.021963
Adjusted R-squared	0.495644	S.D. dependent var	0.059366
S.E. of regression	0.042161	Akaike info criterion	-3.304020
Sum squared resid	0.044438	Schwarz criterion	-2.983390
Log likelihood	59.86432	Hannan-Quinn criter.	-3.197740
F-statistic	6.077413	Durbin-Watson stat	1.821897
Prob(F-statistic)	0.000498		

Source: Author's Computation

Diagnostic Tests

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.110590	Prob. F(2,23)	0.8958
Obs*R-squared	0.304799	Prob. Chi-Square(2)	0.8586

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 08/17/16 Time: 02:48
Sample: 1984 2015
Included observations: 32
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.001323	0.010599	-0.124780	0.9018
D(LFAC(-1))	-0.035247	0.184075	-0.191482	0.8498
D(LADOP(-1))	-0.000644	0.020067	-0.032106	0.9747
D(LEXCH(-1))	-0.001592	0.026601	-0.059849	0.9528
D(LRDS(-1))	0.028493	0.299407	0.095166	0.9250
D(LRDS(-2))	0.021646	0.271006	0.079874	0.9370
ECT(-1)	-0.030368	0.148241	-0.204856	0.8395
RESID(-1)	0.124176	0.291549	0.425917	0.6741
RESID(-2)	0.047491	0.238410	0.199199	0.8439

R-squared	0.009525	Mean dependent var	-4.88E-18
Adjusted R-squared	-0.334988	S.D. dependent var	0.037861
S.E. of regression	0.043746	Akaike info criterion	-3.188590
Sum squared resid	0.044015	Schwarz criterion	-2.776352
Log likelihood	60.01745	Hannan-Quinn criter.	-3.051945
F-statistic	0.027648	Durbin-Watson stat	1.950697
Prob(F-statistic)	0.999991		

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	2.796008	Prob. F(6,25)	0.0320
Obs*R-squared	12.85027	Prob. Chi-Square(6)	0.0455
Scaled explained SS	7.010226	Prob. Chi-Square(6)	0.3199

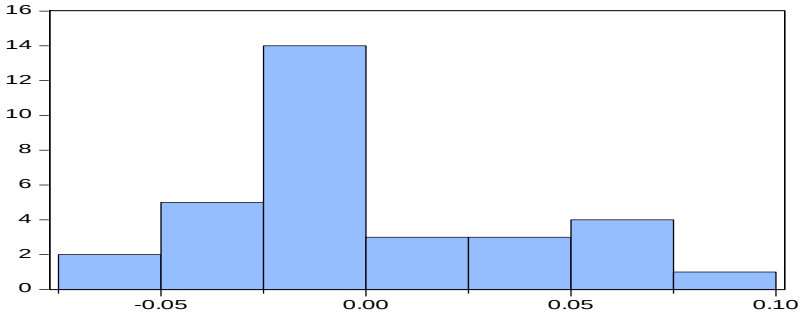
Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 08/17/16 Time: 02:49
Sample: 1984 2015
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001098	0.000379	2.893704	0.0078
D(LFAC(-1))	0.015042	0.006061	2.481563	0.0202
D(LADOP(-1))	0.000422	0.000743	0.568354	0.5749
D(LEXCH(-1))	-0.000829	0.000980	-0.846307	0.4054
D(LRDS(-1))	0.006107	0.010773	0.566913	0.5758
D(LRDS(-2))	0.031728	0.009479	3.347019	0.0026
ECT(-1)	-0.007664	0.004943	-1.550639	0.1336

R-squared	0.401571	Mean dependent var	0.001389
Adjusted R-squared	0.257948	S.D. dependent var	0.001886
S.E. of regression	0.001625	Akaike info criterion	-9.815992
Sum squared resid	6.60E-05	Schwarz criterion	-9.495362
Log likelihood	164.0559	Hannan-Quinn criter.	-9.709712
F-statistic	2.796008	Durbin-Watson stat	2.492815
Prob(F-statistic)	0.032025		

Source: Author's Computation

Residual Normality Tests



Series: Residuals
Sample 1984 2015
Observations 32

Mean	-4.88e-18
Median	-0.007212
Maximum	0.083979
Minimum	-0.072604
Std. Dev.	0.037861
Skewness	0.626611
Kurtosis	2.787597
Jarque-Bera	2.154238
Probability	0.340575

Ramsey RESET Test
Equation: UNTITLED

Specification: D(LFAC) C D(LFAC(-1)) D(LADOP(-1)) D(LEXCH(-1)) D(LRDS(-1)) D(LRDS(-2)) ECT(-1)
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.703906	24	0.1013
F-statistic	2.903295	(1, 24)	0.1013
Likelihood ratio	3.654238	1	0.0559

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.004796	1	0.004796
Restricted SSR	0.044438	25	0.001778
Unrestricted SSR	0.039642	24	0.001652
Unrestricted SSR	0.039642	24	0.001652

LR test summary:

	Value	df
Restricted LogL	59.86432	25
Unrestricted LogL	61.69143	24

Unrestricted Test Equation:
Dependent Variable: D(LFAC)
Method: Least Squares
Date: 08/17/16 Time: 02:50
Sample: 1984 2015
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.018779	0.010956	-1.714025	0.0994
D(LFAC(-1))	0.632004	0.159190	3.970128	0.0006
D(LADOP(-1))	-0.030757	0.019467	-1.580015	0.1272
D(LEXCH(-1))	-0.043285	0.024511	-1.765946	0.0901
D(LRDS(-1))	0.986255	0.274308	3.595423	0.0015
D(LRDS(-2))	-1.035927	0.331830	-3.121861	0.0046
ECT(-1)	-0.569909	0.138573	-4.112693	0.0004
FITTED^2	6.625453	3.888391	1.703906	0.1013

R-squared	0.637155	Mean dependent var	-0.021963
Adjusted R-squared	0.531325	S.D. dependent var	0.059366
S.E. of regression	0.040642	Akaike info criterion	-3.355715
Sum squared resid	0.039642	Schwarz criterion	-2.989281
Log likelihood	61.69143	Hannan-Quinn criter.	-3.234252
F-statistic	6.020554	Durbin-Watson stat	1.956454
Prob(F-statistic)	0.000396		

Source: Author's Computation

Appendix 3.2b: Impact of Food Access on ADOP

VAR Lag Order Selection Criteria
Endogenous variables: LADOP LFAC LEXCH LCPI LACR LRDS
Exogenous variables: C
Date: 08/17/16 Time: 02:54
Sample: 1981 2015
Included observations: 31

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-31.34417	NA	4.48e-07	2.409301	2.686847	2.499774
1	167.0526	307.1950	1.32e-11	-8.067909	-6.125088	-7.434598
2	197.3443	35.17749	2.54e-11	-7.699634	-4.091537	-6.523484

3	244.4138	36.44087	2.99e-11	-8.413792	-3.140420	-6.694804
4	383.6361	53.89252*	4.75e-13*	-15.07330*	-8.134650*	-12.81147*

* 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

Long-Run (Unrestricted) Cointegration Results

Dependent Variable: D(LADOP)
Method: Least Squares
Date: 08/17/16 Time: 03:00
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	16.28909	30.96204	0.526099	0.6177
D(LADOP(-1))	0.048629	1.370931	0.035471	0.9729
D(LADOP(-2))	0.040370	1.038950	0.038856	0.9703
D(LADOP(-3))	-0.082618	0.635566	-0.129992	0.9008
D(FAC(-1))	0.582076	0.377922	1.540203	0.1744
D(LFAC(-2))	2.677678	6.276645	0.426610	0.6845
D(LFAC(-3))	8.107959	5.439296	1.490627	0.1866
D(LEXCH(-1))	0.109673	0.556362	0.197125	0.8502
D(LEXCH(-2))	0.336961	0.496580	0.678563	0.5227
D(LEXCH(-3))	-0.066578	0.518192	-0.128481	0.9020
D(LCPI(-1))	-2.502678	5.218538	-0.479575	0.6485
D(LCPI(-2))	-2.003241	5.650807	-0.354505	0.7351
D(LCPI(-3))	-0.020651	3.474774	-0.005943	0.9955
D(LACR(-1))	-0.154965	0.783357	-0.197821	0.8497
D(LACR(-2))	0.181942	0.618430	0.294200	0.7785
D(LACR(-3))	0.034681	0.377301	0.091919	0.9298
D(LRDS(-1))	5.550730	7.985513	0.695100	0.5130
D(LRDS(-2))	0.042816	8.972220	0.004772	0.9963
D(LRDS(-3))	7.393141	7.348208	1.006115	0.3532
LADOP(-1)	-1.140355	1.688937	-0.675191	0.5247
LFAC(-1)	-5.870922	5.564653	-1.055038	0.3320
LEXCH(-1)	-0.442390	0.467508	-0.946273	0.3805
LCPI(-1)	-0.698289	2.963725	-0.235612	0.8216
LACR(-1)	-0.212822	1.201846	-0.177079	0.8653
LRDS(-1)	1.175672	5.775575	0.203559	0.8454

R-squared	0.773382	Mean dependent var	0.007651
Adjusted R-squared	-0.133089	S.D. dependent var	0.429505
S.E. of regression	0.457193	Akaike info criterion	1.243254
Sum squared resid	1.254153	Schwarz criterion	2.399695
Log likelihood	5.729566	Hannan-Quinn criter.	1.620225
F-statistic	0.853179	Durbin-Watson stat	1.722164
Prob(F-statistic)	0.646298		

Source: Author's Computation

Bounds Tests for Cointegration

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	4.769202	(5, 13)	0.0108
Chi-square	23.84601	5	0.0002

Null Hypothesis: C(14)=C(15)=C(16)=C(17)=C(18)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(14)	-1.086313	0.248838
C(15)	-5.568794	2.550025
C(16)	-0.560274	0.170882
C(17)	-1.036725	0.692472
C(18)	1.620967	1.321895

Restrictions are linear in coefficients.
Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	-4.365550	13	0.0008
F-statistic	19.05803	(1, 13)	0.0008
Chi-square	19.05803	1	0.0000

Null Hypothesis: C(14)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(14)	-1.086313	0.248838

Restrictions are linear in coefficients.

Long-Run (Restricted) Cointegration Results

Dependent Variable: D(LADOP)
Method: Least Squares
Date: 08/17/16 Time: 03:11
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	13.14384	11.47116	1.145817	0.2725
D(LADOP(-3))	-0.121056	0.172302	-0.702581	0.4947
D(FAC(-1))	0.575234	0.217804	2.641059	0.0204
D(LFAC(-2))	2.597166	2.838379	0.915018	0.3768
D(LFAC(-3))	8.256660	2.918423	2.829151	0.0142
D(LEXCH(-1))	0.215137	0.243960	0.881856	0.3939
D(LEXCH(-2))	0.430606	0.252412	1.705967	0.1118
D(LCPI(-1))	-1.966125	1.882017	-1.044690	0.3152
D(LCPI(-2))	-1.636077	1.827346	-0.895329	0.3869
D(LACR(-1))	-0.300956	0.154376	-1.949497	0.0731
D(LACR(-2))	0.084941	0.174955	0.485499	0.6354
D(LRDS(-1))	5.919853	2.910586	2.033904	0.0629
D(LRDS(-3))	7.441828	3.941241	1.888194	0.0815
LADOP(-1)	-1.086313	0.248838	-4.365550	0.0008
LFAC(-1)	-5.568794	2.550025	-2.183819	0.0479
LEXCH(-1)	-0.560274	0.170882	-3.278722	0.0060
LCPI(-1)	-1.036725	0.692472	-1.497136	0.1582
LRDS(-1)	1.620967	1.321895	1.226245	0.2419

R-squared	0.768707	Mean dependent var	0.007651
Adjusted R-squared	0.466248	S.D. dependent var	0.429505
S.E. of regression	0.313789	Akaike info criterion	0.812060
Sum squared resid	1.280026	Schwarz criterion	1.644698
Log likelihood	5.413065	Hannan-Quinn criter.	1.083479
F-statistic	2.541520	Durbin-Watson stat	1.756849
Prob(F-statistic)	0.047037		

Source: Author's Computation

General Error Correction Model

Dependent Variable: D(LADOP)
Method: Least Squares
Date: 08/17/16 Time: 03:16
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.121387	0.181912	-0.667285	0.5135
D(LADOP(-3))	0.042695	0.182532	0.233907	0.8179
D(FAC(-1))	0.063993	0.101350	0.631410	0.5362
D(LFAC(-2))	-2.864746	1.423224	-2.012857	0.0602
D(LFAC(-3))	1.517523	1.611695	0.941569	0.3596
D(LEXCH(-1))	0.100936	0.239866	0.420803	0.6792
D(LEXCH(-2))	0.247791	0.243469	1.017755	0.3231
D(LCPI(-1))	0.289161	1.417599	0.203979	0.8408
D(LCPI(-2))	1.049050	1.283179	0.817540	0.4249
D(LACR(-1))	-0.215686	0.182752	-1.180207	0.2542
D(LACR(-2))	-0.071653	0.178074	-0.402379	0.6924
D(LRDS(-1))	1.657144	2.575689	0.643379	0.5286
D(LRDS(-3))	-0.275032	2.917146	-0.094281	0.9260
ECT(-1)	-0.784524	0.239625	-3.273967	0.0045

R-squared	0.597948	Mean dependent var	0.007651
Adjusted R-squared	0.290496	S.D. dependent var	0.429505
S.E. of regression	0.361781	Akaike info criterion	1.106894
Sum squared resid	2.225048	Schwarz criterion	1.754501
Log likelihood	-3.156858	Hannan-Quinn criter.	1.317998
F-statistic	1.944850	Durbin-Watson stat	1.802275
Prob(F-statistic)	0.099237		

Source: Author's Computation

Parsimonious Error Correction Model

Dependent Variable: D(LADOP)
Method: Least Squares
Date: 08/17/16 Time: 03:30
Sample (adjusted): 1984 2015
Included observations: 32 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.046754	0.061871	-0.755670	0.4559
D(LFAC(-2))	-1.533464	1.054143	-1.454702	0.1565
ECT(-1)	-0.818066	0.179746	-4.551233	0.0001

R-squared	0.463802	Mean dependent var	-0.002278
Adjusted R-squared	0.426823	S.D. dependent var	0.426237
S.E. of regression	0.322697	Akaike info criterion	0.664857
Sum squared resid	3.019876	Schwarz criterion	0.802270
Log likelihood	-7.637710	Hannan-Quinn criter.	0.710405
F-statistic	12.54225	Durbin-Watson stat	1.746155

Prob(F-statistic)	0.000119

Source: Author's Computation

Diagnostic Tests

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.472738	Prob. F(2,27)	0.2471
Obs*R-squared	3.147561	Prob. Chi-Square(2)	0.2073

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 08/17/16 Time: 03:36
Sample: 1984 2015
Included observations: 32
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.024134	0.062543	-0.385885	0.7026
D(LFAC(-2))	-0.769950	1.153975	-0.667216	0.5103
ECT(-1)	-0.672348	0.440792	-1.525318	0.1388
RESID(-1)	0.772145	0.468439	1.648335	0.1109
RESID(-2)	0.127936	0.198139	0.645688	0.5239

R-squared	0.098361	Mean dependent var	-3.42E-18
Adjusted R-squared	-0.035215	S.D. dependent var	0.312114
S.E. of regression	0.317562	Akaike info criterion	0.686315
Sum squared resid	2.722837	Schwarz criterion	0.915337
Log likelihood	-5.981048	Hannan-Quinn criter.	0.762230
F-statistic	0.736369	Durbin-Watson stat	1.824718
Prob(F-statistic)	0.575307		

Source: Author's Computation

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.149975	Prob. F(2,29)	0.8614
Obs*R-squared	0.327590	Prob. Chi-Square(2)	0.8489
Scaled explained SS	0.749826	Prob. Chi-Square(2)	0.6873

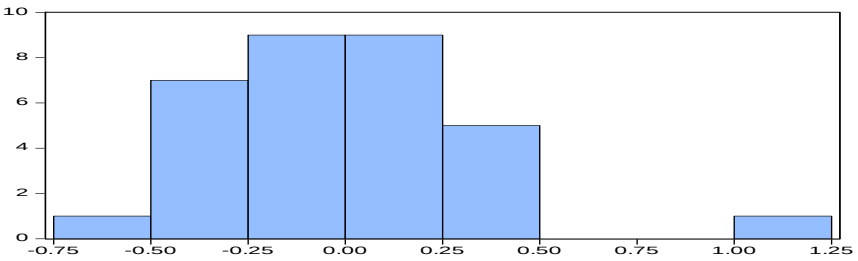
Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 08/17/16 Time: 03:36
Sample: 1984 2015
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.098365	0.044643	2.203359	0.0357
D(LFAC(-2))	0.207202	0.760617	0.272413	0.7872
ECT(-1)	-0.065840	0.129696	-0.507650	0.6155

R-squared	0.010237	Mean dependent var	0.094371
Adjusted R-squared	-0.058022	S.D. dependent var	0.226368
S.E. of regression	0.232843	Akaike info criterion	0.012152
Sum squared resid	1.572254	Schwarz criterion	0.149564
Log likelihood	2.805575	Hannan-Quinn criter.	0.057700

F-statistic	0.149975	Durbin-Watson stat	2.147559
Prob(F-statistic)	0.861393		

Residual Normality Tests



Series: Residuals
Sample 1984 2015
Observations 32

Mean	-3.42e-18
Median	-0.025130
Maximum	1.133337
Minimum	-0.511894
Std. Dev.	0.312114
Skewness	1.442862
Kurtosis	6.573955
Jarque-Bera	28.13408
Probability	0.000001

Ramsey RESET Test
Equation: UNTITLED
Specification: D(LADOP) C D(LFAC(-2)) ECT(-1)
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.433024	28	0.6683
F-statistic	0.187510	(1, 28)	0.6683
Likelihood ratio	0.213583	1	0.6440

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.020089	1	0.020089
Restricted SSR	3.019876	29	0.104134
Unrestricted SSR	2.999787	28	0.107135
Unrestricted SSR	2.999787	28	0.107135

LR test summary:

	Value	df
Restricted LogL	-7.637710	29
Unrestricted LogL	-7.530918	28

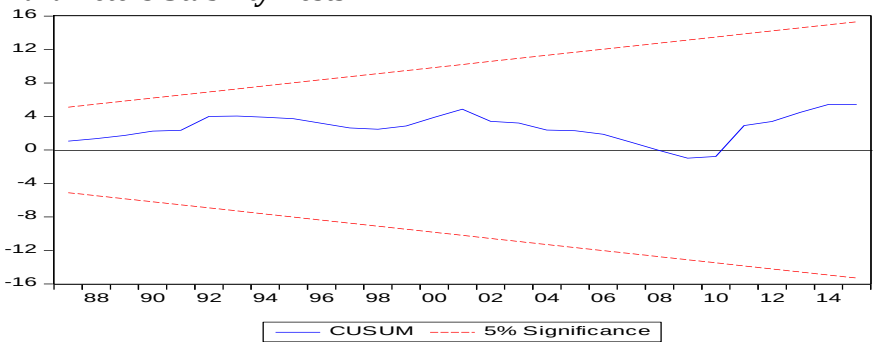
Unrestricted Test Equation:
Dependent Variable: D(LADOP)
Method: Least Squares
Date: 08/17/16 Time: 03:37
Sample: 1984 2015
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.058401	0.068277	-0.855348	0.3996
D(LFAC(-2))	-1.414809	1.103780	-1.281785	0.2104
ECT(-1)	-0.854862	0.201148	-4.249906	0.0002
FITTED^2	0.170810	0.394458	0.433024	0.6683

R-squared	0.467369	Mean dependent var	-0.002278
Adjusted R-squared	0.410301	S.D. dependent var	0.426237
S.E. of regression	0.327315	Akaike info criterion	0.720682
Sum squared resid	2.999787	Schwarz criterion	0.903899
Log likelihood	-7.530918	Hannan-Quinn criter.	0.781414
F-statistic	8.189742	Durbin-Watson stat	1.794366
Prob(F-statistic)	0.000454		

Source: Author's Computation

Parameters Stability Tests



Appendix 3.3a: Impact of ADOP on Food Utilization

Lag Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: LFUT LADOP LRGDP LHLTH LEDF
Exogenous variables: C
Date: 08/17/16 Time: 03:43
Sample: 1981 2015
Included observations: 31

Lag	LogL	LR	FPE	AIC
0	33.35752	NA	1.10e-07	-1.829517
1	162.5429	208.3635*	1.36e-10	-8.551153
2	186.0247	30.29912	1.72e-10	-8.453205
3	222.0665	34.87914	1.25e-10*	-9.165578
4	255.6582	21.67211	1.80e-10	-9.719886*

* 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

Long-Run (Unrestricted) Cointegration R

Dependent Variable: D(LFUT)
Method: Least Squares
Date: 08/17/16 Time: 03:52
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.580971	2.850629	-0.203805	0.8426
D(LFUT(-1))	-0.796666	0.642742	-1.239482	0.2435
D(LFUT(-2))	-0.404766	0.622749	-0.649966	0.5304
D(LFUT(-3))	0.385760	0.552999	0.697578	0.5013
D(LADOP(-1))	-0.014065	0.011798	-1.192184	0.2607
D(LADOP(-2))	-0.004953	0.008279	-0.598313	0.5629
D(LADOP(-3))	0.001282	0.004643	0.276181	0.7880
D(LRGDP(-1))	-0.048197	0.040326	-1.195199	0.2596
D(LRGDP(-2))	0.069596	0.037332	1.864272	0.0919
D(LRGDP(-3))	0.035144	0.036823	0.954407	0.3624
D(LHLTH(-1))	-0.003209	0.004951	-0.648223	0.5314
D(LHLTH(-2))	0.001996	0.004445	0.449067	0.6630
D(LHLTH(-3))	-0.001455	0.003789	-0.384047	0.7090
D(LEDF(-1))	0.005808	0.006016	0.965375	0.3571

D(LEDF(-2))	-0.000472	0.005145	-0.091820	0.9287
D(LEDF(-3))	0.003068	0.003800	0.807372	0.4382
LFUT(-1)	0.105582	0.545152	0.193675	0.8503
LADOP(-1)	0.021459	0.013508	1.588561	0.1432
LRGDP(-1)	0.018422	0.052879	0.348386	0.7348
LHLTH(-1)	0.003501	0.006068	0.576978	0.5767
LEDF(-1)	-0.008422	0.006969	-1.208516	0.2546

R-squared	0.769589	Mean dependent var	-0.002307
Adjusted R-squared	0.308767	S.D. dependent var	0.005510
S.E. of regression	0.004581	Akaike info criterion	-7.710171
Sum squared resid	0.000210	Schwarz criterion	-6.738761
Log likelihood	140.5077	Hannan-Quinn criter.	-7.393516
F-statistic	1.670035	Durbin-Watson stat	2.728743
Prob(F-statistic)	0.203433		

Bounds Tests for Cointegration

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	4.877653	(4, 14)	0.0113
Chi-square	19.51061	4	0.0006

Null Hypothesis: C(14)=C(15)=C(16)=C(17)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(14)	0.243078	0.296017
C(15)	0.024109	0.007300
C(16)	0.034306	0.028303
C(17)	-0.006562	0.003024

Restrictions are linear in coefficients.

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	0.821161	14	0.4253
F-statistic	0.674306	(1, 14)	0.4253
Chi-square	0.674306	1	0.4116

Null Hypothesis: C(14)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(14)	0.243078	0.296017

Restrictions are linear in coefficients.

Long-Run (Restricted) Cointegration Results

Dependent Variable: D(LFUT)
Method: Least Squares
Date: 08/17/16 Time: 04:03
Sample (adjusted): 1985 2015

Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.330123	1.544451	-0.861227	0.4036
D(LFUT(-1))	-0.944523	0.384293	-2.457817	0.0276
D(LFUT(-2))	-0.544415	0.363417	-1.498043	0.1563
D(LFUT(-3))	0.169760	0.215856	0.786449	0.4447
D(LADOP(-1))	-0.016628	0.006570	-2.530972	0.0240
D(LADOP(-2))	-0.006572	0.003991	-1.646861	0.1218
D(LRGDP(-1))	-0.044347	0.032632	-1.359030	0.1956
D(LRGDP(-2))	0.059450	0.027649	2.150196	0.0495
D(LRGDP(-3))	0.028200	0.030242	0.932472	0.3669
D(LHLTH(-1))	-0.001482	0.003040	-0.487457	0.6335
D(LHLTH(-2))	0.002062	0.001701	1.212157	0.2455
D(LEDF(-1))	0.004978	0.003467	1.435799	0.1730
D(LEDF(-3))	0.001666	0.001375	1.211066	0.2459
LFUT(-1)	0.243078	0.296017	0.821161	0.4253
LADOP(-1)	0.024109	0.007300	3.302680	0.0052
LRGDP(-1)	0.034306	0.028303	1.212101	0.2455
LEDF(-1)	-0.006562	0.003024	-2.170022	0.0477

R-squared	0.759147	Mean dependent var	-0.002307
Adjusted R-squared	0.483887	S.D. dependent var	0.005510
S.E. of regression	0.003959	Akaike info criterion	-7.923915
Sum squared resid	0.000219	Schwarz criterion	-7.137535
Log likelihood	139.8207	Hannan-Quinn criter.	-7.667574
F-statistic	2.757924	Durbin-Watson stat	2.636595
Prob(F-statistic)	0.031579		

General Error Correction Model

Dependent Variable: D(LFUT)
Method: Least Squares
Date: 08/17/16 Time: 04:07
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001117	0.002089	0.534804	0.5997
D(LFUT(-1))	0.152723	0.268102	0.569647	0.5764
D(LFUT(-2))	0.452043	0.291291	1.551862	0.1391
D(LFUT(-3))	0.564368	0.232541	2.426963	0.0266
D(LADOP(-1))	0.005225	0.003172	1.647010	0.1179
D(LADOP(-2))	0.004806	0.003122	1.539262	0.1421
D(LRGDP(-1))	-0.035473	0.039853	-0.890116	0.3858
D(LRGDP(-2))	0.037535	0.034234	1.096440	0.2882
D(LRGDP(-3))	0.006804	0.035773	0.190212	0.8514
D(LHLTH(-1))	-0.002029	0.003821	-0.530914	0.6023
D(LHLTH(-2))	-0.000803	0.001597	-0.503093	0.6214
D(LEDF(-1))	-0.000764	0.003813	-0.200405	0.8435
D(LEDF(-3))	-0.000323	0.001382	-0.233825	0.8179
ECT(-1)	-0.459126	0.243407	-1.886249	0.0765

R-squared	0.523267	Mean dependent var	-0.002307
Adjusted R-squared	0.158706	S.D. dependent var	0.005510
S.E. of regression	0.005054	Akaike info criterion	-7.434692
Sum squared resid	0.000434	Schwarz criterion	-6.787085
Log likelihood	129.2377	Hannan-Quinn criter.	-7.223588
F-statistic	1.435335	Durbin-Watson stat	2.194364

Prob(F-statistic)	0.239140			

Parsimonious Error Correction Model

Dependent Variable: D(LFUT)
Method: Least Squares
Date: 08/17/16 Time: 04:20
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000860	0.001621	0.530580	0.6010
D(LFUT(-2))	0.345497	0.197342	1.750752	0.0939
D(LFUT(-3))	0.529110	0.187918	2.815636	0.0101
D(LADOP(-1))	0.004982	0.002293	2.173015	0.0408
D(LADOP(-2))	0.004767	0.002520	1.891800	0.0718
D(LRGDP(-1))	-0.042763	0.031967	-1.337713	0.1947
D(LRGDP(-2))	0.032782	0.028726	1.141162	0.2661
D(LHLTH(-1))	-0.002154	0.001027	-2.096727	0.0477
ECT(-1)	-0.338918	0.149026	-2.274217	0.0331

R-squared	0.502074	Mean dependent var	-0.002307
Adjusted R-squared	0.321010	S.D. dependent var	0.005510
S.E. of regression	0.004541	Akaike info criterion	-7.713778
Sum squared resid	0.000454	Schwarz criterion	-7.297459
Log likelihood	128.5636	Hannan-Quinn criter.	-7.578069
F-statistic	2.772909	Durbin-Watson stat	2.021681
Prob(F-statistic)	0.027687		

Diagnostic Tests

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.124559	Prob. F(2,20)	0.8836
Obs*R-squared	0.381381	Prob. Chi-Square(2)	0.8264

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 08/17/16 Time: 04:21
Sample: 1985 2015
Included observations: 31
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.06E-05	0.001718	-0.029453	0.9768
D(LFUT(-2))	-0.106196	0.296999	-0.357564	0.7244
D(LFUT(-3))	-0.036698	0.209713	-0.174993	0.8628
D(LADOP(-1))	-0.000304	0.002644	-0.115160	0.9095
D(LADOP(-2))	-0.000261	0.002722	-0.095863	0.9246
D(LRGDP(-1))	-0.001945	0.034089	-0.057045	0.9551
D(LRGDP(-2))	-0.003762	0.030890	-0.121785	0.9043
D(LHLTH(-1))	1.73E-05	0.001075	0.016075	0.9873
ECT(-1)	-7.79E-05	0.194961	-0.000400	0.9997
RESID(-1)	-0.014975	0.304961	-0.049106	0.9613
RESID(-2)	0.175337	0.361080	0.485592	0.6325

R-squared	0.012303	Mean dependent var	-4.34E-19

Adjusted R-squared	-0.481546	S.D. dependent var	0.003888
S.E. of regression	0.004733	Akaike info criterion	-7.597125
Sum squared resid	0.000448	Schwarz criterion	-7.088291
Log likelihood	128.7554	Hannan-Quinn criter.	-7.431258
F-statistic	0.024912	Durbin-Watson stat	1.874114
Prob(F-statistic)	0.999999		

Heteroskedasticity Test: Breusch-Pagan-Godfrey

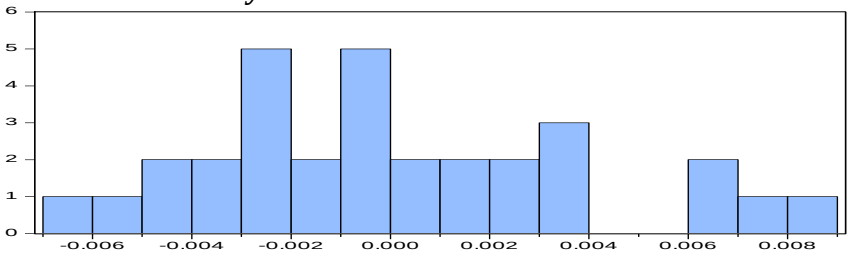
F-statistic	0.639366	Prob. F(8,22)	0.7366
Obs*R-squared	5.847801	Prob. Chi-Square(8)	0.6643
Scaled explained SS	2.420876	Prob. Chi-Square(8)	0.9653

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 08/17/16 Time: 04:21
Sample: 1985 2015
Included observations: 31

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.01E-05	7.16E-06	1.409174	0.1728
D(LFUT(-2))	-0.000752	0.000872	-0.862304	0.3978
D(LFUT(-3))	-0.000532	0.000830	-0.640997	0.5281
D(LADOP(-1))	1.93E-07	1.01E-05	0.019083	0.9849
D(LADOP(-2))	-3.59E-06	1.11E-05	-0.322391	0.7502
D(LRGDP(-1))	1.24E-05	0.000141	0.087557	0.9310
D(LRGDP(-2))	1.12E-05	0.000127	0.088504	0.9303
D(LHLTH(-1))	1.91E-06	4.54E-06	0.420311	0.6783
ECT(-1)	-0.000867	0.000658	-1.317179	0.2013

R-squared	0.188639	Mean dependent var	1.46E-05
Adjusted R-squared	-0.106402	S.D. dependent var	1.91E-05
S.E. of regression	2.01E-05	Akaike info criterion	-18.55802
Sum squared resid	8.85E-09	Schwarz criterion	-18.14170
Log likelihood	296.6493	Hannan-Quinn criter.	-18.42231
F-statistic	0.639366	Durbin-Watson stat	1.678403
Prob(F-statistic)	0.736640		

Residual Normality Tests



Series: Residuals
Sample 1985 2015
Observations 31

Mean	-4.34e-19
Median	-0.000433
Maximum	0.008551
Minimum	-0.006639
Std. Dev.	0.003888
Skewness	0.511317
Kurtosis	2.643947
Jarque-Bera	1.514550
Probability	0.468943

Ramsey RESET Test
Equation: UNTITLED
Specification: D(LFUT) C D(LFUT(-2)) D(LFUT(-3)) D(LADOP(-1)) D(LADOP(-2)) D(LRGDP(-1)) D(LRGDP(-2)) D(LHLTH(-1)) ECT(-1)
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.451858	21	0.1613
F-statistic	2.107892	(1, 21)	0.1613
Likelihood ratio	2.965205	1	0.0851

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	4.14E-05	1	4.14E-05
Restricted SSR	0.000454	22	2.06E-05
Unrestricted SSR	0.000412	21	1.96E-05
Unrestricted SSR	0.000412	21	1.96E-05

LR test summary:

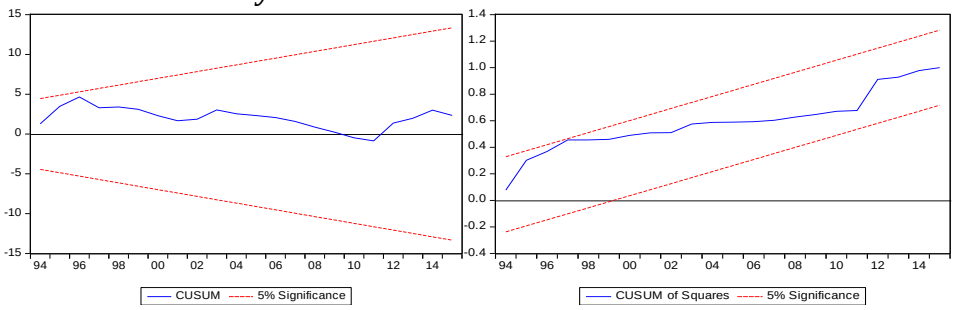
	Value	df
Restricted LogL	128.5636	22
Unrestricted LogL	130.0462	21

Unrestricted Test Equation:
Dependent Variable: D(LFUT)
Method: Least Squares
Date: 08/17/16 Time: 04:22
Sample: 1985 2015
Included observations: 31

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000501	0.001601	0.312843	0.7575
D(LFUT(-2))	0.320204	0.193340	1.656176	0.1126
D(LFUT(-3))	0.538212	0.183465	2.933589	0.0079
D(LADOP(-1))	0.005764	0.002301	2.505013	0.0206
D(LADOP(-2))	0.004772	0.002458	1.941054	0.0658
D(LRGDP(-1))	-0.053207	0.032010	-1.662196	0.1113
D(LRGDP(-2))	0.030144	0.028088	1.073190	0.2954
D(LHLTH(-1))	-0.002142	0.001002	-2.137465	0.0445
ECT(-1)	-0.339553	0.145410	-2.335136	0.0295
FITTED^2	48.24027	33.22658	1.451858	0.1613

R-squared	0.547495	Mean dependent var	-0.002307
Adjusted R-squared	0.353564	S.D. dependent var	0.005510
S.E. of regression	0.004430	Akaike info criterion	-7.744914
Sum squared resid	0.000412	Schwarz criterion	-7.282337
Log likelihood	130.0462	Hannan-Quinn criter.	-7.594125
F-statistic	2.823143	Durbin-Watson stat	1.745525
Prob(F-statistic)	0.024020		

Parameters Stability Tests



Appendix 3.3b: Impact of FUT on ADOP

Long-Run (Unrestricted) Cointegration Results

Dependent Variable: D(LADOP)

Method: Least Squares
Date: 08/17/16 Time: 04:27
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-240.9851	242.1713	-0.995102	0.3432
D(LADOP(-1))	-1.072110	1.002275	-1.069676	0.3099
D(LADOP(-2))	-1.088906	0.703316	-1.548246	0.1526
D(LADOP(-3))	-0.542338	0.394460	-1.374887	0.1992
D(LFUT(-1))	-29.57324	54.60323	-0.541603	0.6000
D(LFUT(-2))	-86.44556	52.90481	-1.633983	0.1333
D(LFUT(-3))	-76.12509	46.97923	-1.620399	0.1362
D(LRGDP(-1))	-4.729166	3.425827	-1.380445	0.1975
D(LRGDP(-2))	-2.915613	3.171462	-0.919328	0.3796
D(LRGDP(-3))	-3.678844	3.128236	-1.176012	0.2668
D(LHLTH(-1))	0.093488	0.420590	0.222277	0.8286
D(LHLTH(-2))	0.294052	0.377627	0.778682	0.4542
D(LHLTH(-3))	0.067975	0.321889	0.211176	0.8370
D(LEDF(-1))	0.167007	0.511087	0.326768	0.7506
D(LEDF(-2))	-0.117606	0.437118	-0.269049	0.7934
D(LEDF(-3))	-0.094742	0.322830	-0.293473	0.7752
LADOP(-1)	0.369238	1.147588	0.321751	0.7543
LFUT(-1)	43.82285	46.31264	0.946240	0.3663
LRGDP(-1)	5.192376	4.492240	1.155854	0.2746
LHLTH(-1)	-1.037205	0.515483	-2.012105	0.0719
LEDF(-1)	0.534516	0.592013	0.902879	0.3878

R-squared	0.726278	Mean dependent var	0.007651
Adjusted R-squared	0.178833	S.D. dependent var	0.429505
S.E. of regression	0.389210	Akaike info criterion	1.174039
Sum squared resid	1.514841	Schwarz criterion	2.145450
Log likelihood	2.802392	Hannan-Quinn criter.	1.490695
F-statistic	1.326668	Durbin-Watson stat	1.872816
Prob(F-statistic)	0.330985		

Bounds Tests for Cointegration

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	2.952395	(4, 15)	0.0553
Chi-square	11.80958	4	0.0188

Null Hypothesis: C(13)=C(14)=C(15)=C(16)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(13)	34.93868	16.23904
C(14)	4.161667	1.535136
C(15)	-0.820096	0.294869
C(16)	0.433295	0.265141

Restrictions are linear in coefficients.

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability

t-statistic	2.151523	15	0.0481
F-statistic	4.629052	(1, 15)	0.0481
Chi-square	4.629052	1	0.0314

Null Hypothesis: C(13)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(13)	34.93868	16.23904

Restrictions are linear in coefficients.

Long-Run (Restricted) Cointegration Results

Dependent Variable: D(LADOP)
Method: Least Squares
Date: 08/17/16 Time: 05:04
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-193.0631	85.13964	-2.267606	0.0386
D(LADOP(-1))	-0.747099	0.208062	-3.590758	0.0027
D(LADOP(-2))	-0.798992	0.272320	-2.934024	0.0103
D(LADOP(-3))	-0.412060	0.220362	-1.869920	0.0811
D(LFUT(-1))	-18.41224	18.14975	-1.014462	0.3264
D(LFUT(-2))	-68.69356	20.13090	-3.412344	0.0039
D(LFUT(-3))	-64.53531	20.27180	-3.183502	0.0062
D(LRGDP(-1))	-4.336105	2.624852	-1.651942	0.1193
D(LRGDP(-2))	-2.721519	2.336798	-1.164636	0.2624
D(LRGDP(-3))	-3.520329	2.526017	-1.393629	0.1837
D(LHLTH(-2))	0.163658	0.100646	1.626071	0.1248
D(LEDF(-1))	0.179820	0.120483	1.492494	0.1563
LFUT(-1)	34.93868	16.23904	2.151523	0.0481
LRGDP(-1)	4.161667	1.535136	2.710944	0.0161
LHLTH(-1)	-0.820096	0.294869	-2.781221	0.0140
LEDF(-1)	0.433295	0.265141	1.634204	0.1230

R-squared	0.709453	Mean dependent var	0.007651
Adjusted R-squared	0.418906	S.D. dependent var	0.429505
S.E. of regression	0.327409	Akaike info criterion	0.911110
Sum squared resid	1.607953	Schwarz criterion	1.651232
Log likelihood	1.877799	Hannan-Quinn criter.	1.152371
F-statistic	2.441783	Durbin-Watson stat	1.804729
Prob(F-statistic)	0.047101		

General Error Correction Model

Dependent Variable: D(LADOP)
Method: Least Squares
Date: 08/17/16 Time: 05:11
Sample (adjusted): 1985 2015
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.047151	0.150932	0.312397	0.7583
D(LADOP(-1))	-0.254588	0.360477	-0.706253	0.4891
D(LADOP(-2))	-0.244758	0.351834	-0.695665	0.4955
D(LADOP(-3))	-0.078849	0.249680	-0.315798	0.7558
D(LFUT(-1))	11.44437	17.84659	0.641264	0.5294
D(LFUT(-2))	-16.56339	19.27451	-0.859342	0.4015

D(LFUT(-3))	-17.43553	17.81494	-0.978703	0.3407
D(LRGDP(-1))	-2.609258	2.940547	-0.887338	0.3866
D(LRGDP(-2))	-0.604369	2.523709	-0.239476	0.8134
D(LRGDP(-3))	0.703679	2.186971	0.321760	0.7513
D(LHLTH(-2))	0.144814	0.107923	1.341824	0.1963
D(LEDF(-1))	-0.022124	0.119644	-0.184911	0.8554
ECT(-1)	-0.475615	0.342481	-1.388735	0.1819

R-squared	0.530959	Mean dependent var	0.007651
Adjusted R-squared	0.218264	S.D. dependent var	0.429505
S.E. of regression	0.379750	Akaike info criterion	1.196487
Sum squared resid	2.595781	Schwarz criterion	1.797836
Log likelihood	-5.545548	Hannan-Quinn criter.	1.392512
F-statistic	1.698011	Durbin-Watson stat	1.990614
Prob(F-statistic)	0.150326		

Parsimonious Error Correction Model

Dependent Variable: D(LADOP)
Method: Least Squares
Date: 08/17/16 Time: 05:42
Sample (adjusted): 1984 2015
Included observations: 32 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.027504	0.065475	-0.420068	0.6776
D(LFUT(-1))	12.90925	10.97852	1.175864	0.2496
D(LHLTH(-2))	0.165571	0.075051	2.206103	0.0358
ECT(-1)	-0.627324	0.178081	-3.522688	0.0015

R-squared	0.439366	Mean dependent var	-0.002278
Adjusted R-squared	0.379298	S.D. dependent var	0.426237
S.E. of regression	0.335809	Akaike info criterion	0.771922
Sum squared resid	3.157499	Schwarz criterion	0.955139
Log likelihood	-8.350745	Hannan-Quinn criter.	0.832653
F-statistic	7.314489	Durbin-Watson stat	1.904151
Prob(F-statistic)	0.000906		

Diagnostic Tests

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.090699	Prob. F(2,26)	0.9136
Obs*R-squared	0.221713	Prob. Chi-Square(2)	0.8951

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 08/17/16 Time: 05:45
Sample: 1984 2015
Included observations: 32
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003712	0.068526	0.054169	0.9572
D(LFUT(-1))	2.881713	13.57061	0.212350	0.8335
D(LHLTH(-2))	0.002512	0.079414	0.031631	0.9750
ECT(-1)	-0.072191	0.407161	-0.177304	0.8606
RESID(-1)	0.107104	0.430729	0.248657	0.8056

RESID(-2)	-0.060415	0.227531	-0.265522	0.7927

R-squared	0.006929	Mean dependent var	-2.21E-17
Adjusted R-squared	-0.184047	S.D. dependent var	0.319147
S.E. of regression	0.347276	Akaike info criterion	0.889969
Sum squared resid	3.135623	Schwarz criterion	1.164794
Log likelihood	-8.239503	Hannan-Quinn criter.	0.981066
F-statistic	0.036280	Durbin-Watson stat	1.927732
Prob(F-statistic)	0.999208		

Heteroskedasticity Test: Breusch-Pagan-Godfrey

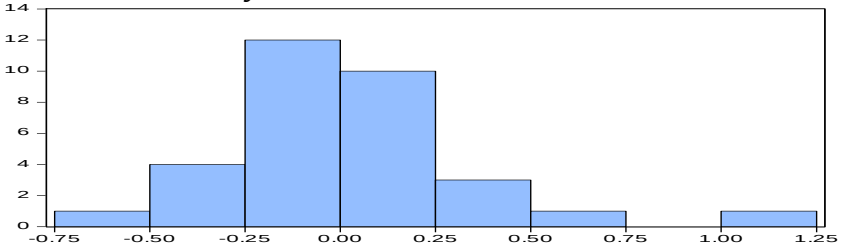
F-statistic	0.870080	Prob. F(3,28)	0.4682
Obs*R-squared	2.728750	Prob. Chi-Square(3)	0.4354
Scaled explained SS	5.959463	Prob. Chi-Square(3)	0.1136

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 08/17/16 Time: 05:45
Sample: 1984 2015
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.080635	0.046984	1.716237	0.0972
D(LFUT(-1))	-10.51464	7.877978	-1.334688	0.1927
D(LHLTH(-2))	-0.033248	0.053855	-0.617352	0.5420
ECT(-1)	-0.089643	0.127787	-0.701499	0.4888

R-squared	0.085273	Mean dependent var	0.098672
Adjusted R-squared	-0.012733	S.D. dependent var	0.239451
S.E. of regression	0.240970	Akaike info criterion	0.108183
Sum squared resid	1.625868	Schwarz criterion	0.291400
Log likelihood	2.269077	Hannan-Quinn criter.	0.168914
F-statistic	0.870080	Durbin-Watson stat	2.259939
Prob(F-statistic)	0.468244		

Residual Normality Tests



Series: Residuals
Sample 1984 2015
Observations 32

Mean	-2.21e-17
Median	-0.028371
Maximum	1.160501
Minimum	-0.527278
Std. Dev.	0.319147
Skewness	1.527501
Kurtosis	6.705021
Jarque-Bera	30.74695
Probability	0.000000

Ramsey RESET Test
Equation: UNTITLED
Specification: D(LADOP) C D(LFUT(-1)) D(LHLTH(-2)) ECT(-1)
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.156114	27	0.8771
F-statistic	0.024372	(1, 27)	0.8771

Likelihood ratio	0.028872	1	0.8651

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.002848	1	0.002848
Restricted SSR	3.157499	28	0.112768
Unrestricted SSR	3.154652	27	0.116839
Unrestricted SSR	3.154652	27	0.116839

LR test summary:

	Value	df
Restricted LogL	-8.350745	28
Unrestricted LogL	-8.336309	27

Unrestricted Test Equation:
Dependent Variable: D(LADOP)
Method: Least Squares
Date: 08/17/16 Time: 05:46
Sample: 1984 2015
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.021444	0.077125	-0.278049	0.7831
D(LFUT(-1))	12.77174	11.20959	1.139358	0.2646
D(LHLTH(-2))	0.173322	0.091111	1.902326	0.0678
ECT(-1)	-0.614036	0.200254	-3.066290	0.0049
FITTED^2	-0.102554	0.656919	-0.156114	0.8771

R-squared	0.439872	Mean dependent var	-0.002278
Adjusted R-squared	0.356890	S.D. dependent var	0.426237
S.E. of regression	0.341817	Akaike info criterion	0.833519
Sum squared resid	3.154652	Schwarz criterion	1.062541
Log likelihood	-8.336309	Hannan-Quinn criter.	0.909433
F-statistic	5.300811	Durbin-Watson stat	1.884609
Prob(F-statistic)	0.002774		

Parameters Stability Tests

