Oil price volatility spillover effects on food prices in Nigeria

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Abstract

Studies have been done on oil price volatility spillover effects on the prices of food in both pre-crisis and post-crisis periods. However, what has been sparingly studied is oil price volatility spillover effects on urban prices of food and rural prices of food. The disparity in the rural-urban spending in Nigeria is an area that can further be explored by evaluating the effects of oil price volatility spillover on prices of food in these areas. This study therefore adopts GARCH (1, 1)-TY model to evaluate the impulse response function and variance decomposition of these effects on prices of food in pre-crisis and post-crisis periods. Findings show that in full sample and post-crisis periods both aggregate price of food (APF) and urban average price of food (APFU) positively respond to oil price shocks while rural average price of food (APFR) responds negatively to oil price shocks. However, the response of the urban average price of food proves to be more significant in the post-crisis periods as it appears relatively most affected in this period by a greater percentage of oil price shocks.

Keywords:
GARCH (1, 1), TY, APF, APFR, APFU, Oil price volatility spillover, Impulse Response Function, Variance Decomposition

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1.1 INTRODUCTION

The bane of fluctuation in the general prices of goods and services in Nigeria may be assumed to be majorly exogenous and arises from oil prices and exchange rate changes. This is because Nigeria is a net importer of most basic commodities such as refined oil and foods. Chuku [1] in his analysis of the oil price-macro economy relations revealed that oil prices are strictly exogenous to the Nigerian economy because economic activities within the country have insignificant influence on the global oil market, given that Nigeria is a major exporter of crude oil. Nevertheless, undermining the menace of pipeline vandalization, insecurity and poor infrastructure on food and oil availability and affordability is assuming difficulties away. Fluctuations in the price of oil basically affect every other economic activity within the country. This is because oil remains the engine room of the Nigerian economy both as a source of foreign income earning and a source for powering industrial, manufacturing and agricultural activities.

Studies have shown that the spillover effects of the activities in the oil sector on agricultural sector and beyond in Nigeria is debatable. Oyekunle [2] explained that there has been a decline in the fortune of the agricultural sector over the years from been a major contributor to GDP and supplier of food, income, employment and foreign exchange in the 1960s to a net importer of food thereby contributing less to total foreign exchange earnings in the present day Nigeria. This neglect was argued to be attributable to the discovery of petroleum resources beginning from the early 1970s and its accompanying foreign exchange returns. Not only was farming abandoned but also was the structure of domestic demand for food and agricultural products altered in favour of the imported grains, beverages, vegetable oils and fibres, which Nigeria was once reputed as a leading world producer. This also increased the average price of food.

Coupled with the inability of the government to protect the economy from global oil price shocks, is the absence of inadequate substitutes for oil as a source of power by both private and public sectors. This implies that the demand for oil is inelastic at all levels, hence, any (negative) shock in oil price leads to general rise in the average prices of goods and services due to high cost of production (Tule et al. [3]). Binuomote and Odeniyi [4] explained that effort put in place to ensure that agriculture reclaims its lost glory as the mainstay of the economy may be daunting. This is because it will require finding solution to the negative effects that oil price fluctuations have on the Nigerian agricultural sector among other things. Evident in this is the recent price hikes and spikes accompanied by recession which raised concern among consumers and policy makers in Nigeria. Oil sector is the driving force of virtually all other important sectors of the economy, hence, fluctuation in its price will alter agricultural cost of production leading to higher prices of food. This is the effect of oil price fluctuation Binuomote and Odeniyi [4] referred to.

In order to reduce the menace of oil price shock on the consumer and producer purchases, Nigerian government employs dual pricing mechanism for fuel. While marketers are allowed to fix the domestic price of diesel which has been completely deregulated, prices of PMS and DPK are regulated by government with the aid of subsidy schemes by different administrations which could not be sustained due to weak institutions (Ozo-Eson and Muttaqa, [5]). This was revealed as Nigeria was not exempted from the 2007-2008 global food crisis which was attributable to rising energy prices, exchange rate instability and low interest rate. Olomola [6] corroborated the argument that the 2008 food crisis was a consequence of price changes in the international market and the unprecedented increase in the price of refined imported oil into Nigeria as the cost of agricultural inputs and transportation cost skyrocketed. It is therefore inevitable to weigh the spillover effects of oil price shock on the average price of food in Nigeria.

1.2 Statement of Problem

The huge resources that have been invested in the agricultural sector by both private and public agencies to ensure that it reclaims its lost glory cannot be overemphasised. However, the sector has failed to yield corresponding returns. The rate of food insecurity is becoming alarming due to the inability to access enough food for a healthy standard of living in a country where majority are low income earners (Reutlinger, [7]). Having acknowledged that the Nigerian agricultural sector became sick after the discovery of petroleum in the 70s, it is therefore, necessary to examine oil price volatility spillover effects on the prices of food in Nigeria. In summary, it is of paramount importance to examine whether the spillover of oil price volatility to average price of food is time variant and relatively high in magnitude or not.

1.3 Research Question

The research seeks to provide answers to the following questions:

1. Is there co-movement between oil price volatility and average prices of food in Nigeria?
2. If there is co-movement, it is of what direction?
3. What is the magnitude of the spillover effects of oil price shock on average price of food in Nigeria?

1.4 Objective of the Study

The overall objective of this study is to empirically analyse the spillover effects of oil price volatility on the average price of food in Nigeria by looking at the pre-crisis periods and post-crisis periods of 2006/2008.Specifically, the objectives of the research project are to evaluate the following:

1. Oil price volatility spillover effects on average price of food in Nigeria's rural areas
2. Oil price volatility spillover effects on average price of food in Nigeria's urban areas

1.5 Justification of the Study

This study is embarked upon, to show, that the diversification of the Nigerian economy away from been fuel dependent as a source of energy to a more sustainable, less volatile, cost effective and domestically sourced sources of energy is inevitable. This must be accompanied by the enactment and implementation of agricultural and infrastructural development policies that encourage farming for economic development as it will lead to availability and affordability of food under conducive farming conditions and ease of distribution. The need for import substitution strategies in the areas of importing refined petroleum to help protect the Nigerian economy from external oil price shock s of refined imported fuel is utmostly echoed by this study.

1.6 Scope of the Study

In studying the spillover effects of oil price volatility on average price of food in Nigeria, the research uses monthly data from January 2000 to April 2006 for pre-crisis periods and May 2006 to December 2016 for post-crisis periods.

1.7 Layout of the Study

The study introduces the project topic and states the problem, questions, objectives, justification, scope and layout of the study. This is followed by the background to the study which summarises the relationship between the agricultural sector and the oil industry in Nigeria while the next chapter covers the review of relevant literature and theoretical framework. Revelations on the research methodology is contained in the chapter that follows and succeeded by data findings and analysis. The final chapter presents the summary, conclusions and recommendations.

BACKGROUND TO THE STUDY

2.1 Brief History of the Impact of Agriculture on the Nigerian Economy

Nigeria is a country, popularly tagged “a land of milk and honey” because of its enormous mineral and natural resources. Nigeria is rich in soils favourable for farming, waters conducive for fishing and mineral resources such as tin, crude oil and limestone among the host of others. The evolution of food production in Nigeria is as old as the country itself. An agrarian society mainly sustained by agriculture through provision of employment, raw materials, food and foreign exchange earnings. Nwankpa [8] argued that the Nigerian economy was greatly sustained by agriculture at independence as it contributed 63.49 percent to the GDP and significantly pivoted the first national development plan. Samuel [9] further explains that the Nigerian economy was mainly sustained by cotton, palm oil, rubber, cocoa and groundnut which were the major agricultural products. Corroborating this argument, Folawewo and Olakojo [10] also argued that before the oil price shock of 1970 and early 1980s agricultural was the mainstay of the Nigerian economy as Nigeria was one of the largest exporters of agricultural commodities.

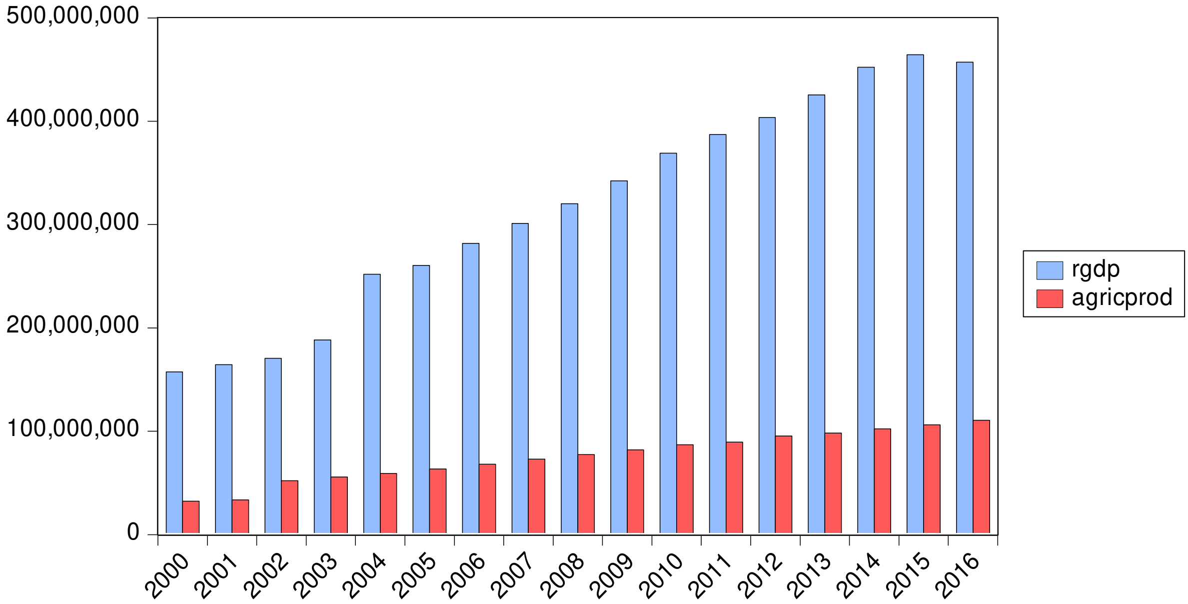
Also, the strength of the colonial Nigerian agricultural sector, advanced the economic development of the three regions that culminated the then Nigeria. In order to sustain this contribution, the Nigerian government came up with various agricultural schemes and policies. For example, the government promulgated agricultural policies that encouraged rural people to produce cash crops like cocoa in the western region, oil-palm in the eastern region, rubber in the mid-western Nigeria and groundnut and cotton in the northern region (Yusuf, [11]). This is evident in the free education, a popular educational policy of the then Western region, hugely supported by the proceeds from cocoa production, while proceeds from groundnuts were used to finance various developmental projects in the Northern region and gains from palm oil in the Eastern region played vital roles in ensuring the region was not left behind (see Familugba, [12]; Ugwu and Kanu, [13]; Akpan, [14]; Dodondawa, [15]).

The transformation of the agricultural sector led to simultaneous development of the transport sector. To enhance adequate movement of cash crops to Europe, the colonial authorities constructed railways across the regions. During this period a commodity approach was employed which led to the establishment of some agricultural research institutes in Samaru, 1921, Umudike, 1924 and Moor plantation, 1924 (Yusuf, [11]).

By 1960 agricultural and rural development took another dimension, rural road construction been the order of the day. However, the progress recorded in the agricultural sector was disrupted by the civil war which started in 1967 and ended in 1970 (Akpan, [14]).

Fig. 2 below shows the annual contribution of agriculture to real gross domestic product in Nigeria. Between 2000 and 2016, real gross domestic product consistently increases, while it declines in 2016 as a result of recession. Although, agricultural production increases over the years, but its contribution to real gross domestic product increases at a constant rate as it hovers around an average of 20% per year except for year 2002 which is 30%.

Fig. 2.0



Annual data for real agricultural value added and real gross domestic product from 2000 to 2016
Source: World Bank Data Indicator

2.2 The Effects of the Emergence of Oil on the Nigerian Agricultural Sector

The termination of the civil war ushered in an era of crude oil exploration in the 1970s. The discovery of oil was expected to enhance the progress already recorded in the agricultural sector as an employer of labour, provider of food and foreign exchange earner. However, these achievements were short lived. While a school of thought believes that oil is responsible for the poor performance of the agricultural sector another school of thought disagrees. Akpan [14] argued that the discovery of oil had more impact on the agricultural sector than any other sector as the country shifts from being a self-sufficient country in the production of staple food into a net importer of food by mid-1970s. Contrary to this, Ammani [16] explained that the poor performance of the agricultural sector in Nigeria could not be linked to the neglect of the agricultural sector as a result of oil boom. He argues that the decline in the sector could be as a result of Dutch disease, natural resources curse and rent seeking idea among the host of others. Whether agricultural sector was neglected or not as a result of oil boom, the fact remains that it performed poorly after the discovery of oil.

2.3 Efforts on the Part of the Nigerian Government to Correct the Anomalies Between the Two Sectors

Acknowledging this fact, subsequent governments after independence came up with different agricultural policies and programmes in order to help agriculture reclaim its rightful place as the mainstay of the Nigerian economy. Daneji [17] explained that various intervention programmes have been embarked upon by subsequent governments in Nigeria to ensure self-sufficiency in food production. For example, Agricultural Development Programmes (ADPs) was established in 1972 to close the infrastructural decay gap in Northern Nigeria, Operation Feed the Nation (OFN) was established in 1976 to ameliorate the escalating food crisis, rural-urban migration and net food import and Green Revolution Programme (GR) was established in 1979 to replace Operation Feed the Nation in order to achieve rapid and radical transformation and abort inherited food problems of previous governments and National Agricultural Land Development Authority (NALDA) was established in 1992 to achieve moderation in the problems of inadequate utilization of abundant agricultural land.

Corroborating this argument, a report by PriceWaterhouseCoopers (PWC) [18] explained that to ensure the availability and affordability of food, government in 2012 established the Agricultural Transformation Agenda (ATA). It was introduced to improve farmers' standard of living, food prices, employment and transform the country to a leading player in the domestic and international food markets. Also, the present administration recently introduced Agricultural Promotion Policy (APP) and Economic Recovery Growth Plan (ERGP). The former is aimed at solving the problem of food shortages and improving output quality able to compete favourably, while the latter is aimed at ensuring food security and adequate supply of tomato-paste, rice and wheat by 2017, 2018, 2019 and 2020 respectively. The Lagos-Kebbi Rice, popularly called the LAKE Rice is one of the outcomes of the ERGP.

Despite these policy and programme interventions, foods have remained inadequate in supply and unaffordable in Nigeria. For example, Nigeria was not exempted from the global food crisis of 2007 and 2008 with all the agricultural interventions. This is a pointer to the fact that there are exogenous factors that influence the availability and affordability of agricultural products beyond agricultural policies and programme interventions. Olomola [6] argued that the food crisis of 2008 was attributable to price fluctuations in the world market and escalation of the imported oil price into Nigeria which led to high cost of production of agricultural outputs. In summary, Olomola [6] explained that the food crisis of 2008 in Nigeria was a resultant effect of the spillover from oil price fluctuation, exchange rate instability, insecurity and poor implementation of projects.

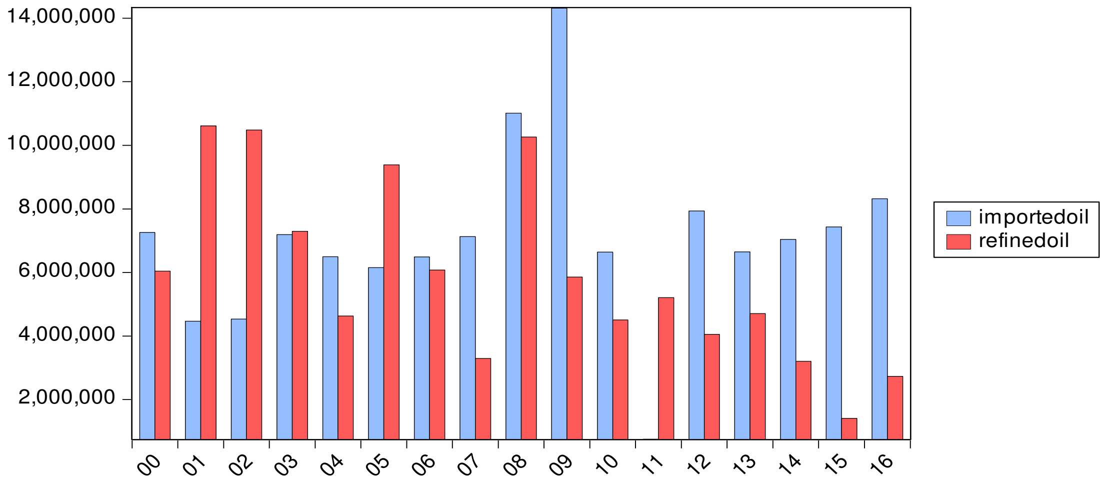
The dependency of the Nigerian economy on the volatile oil sector cannot be overemphasised. Absence of oil in the Nigerian economy will render the manufacturing, industrial and agricultural sectors redundant as at this period. The bedrock of modern or mechanized agricultural sector is the oil sector. Sophisticated agricultural machineries are powered by oil; agricultural processing machineries for agricultural finished products are powered by oil and the distribution of agricultural final products is also made possible by oil used in the transport sector. Nigeria is a replica of an economy faced by epileptic power supply, where the economy is powered by generators which are imported and fuel powered. This implies that Nigeria is vulnerable to shocks from oil prices.

Since Nigeria is a net importer of food and oil, fluctuation of prices in the global markets, creeps into the Nigerian economy, causing general price instability. Nigeria faces the effects of price shocks from importing oil and exporting oil. Crude oil price is solely determined by OPEC, independent of the economic situation obtainable in individual member countries. Being a supplier of crude oil, this price forms one of the determinant factors upon which the Nigerian Budget is bench marked, hence, any shock affects her economy as a whole. On the other hand, Nigeria imports Premium Motor Spirit (PMS), Dual Purpose Kerosene (DPK), Automotive Gas Oil (AGO) and cooking gas which makes Nigeria vulnerable to imported inflation. In discussing the relationship between oil price shock and economic growth in Nigeria, Aliyu [19] explained that, Nigeria currently imports about 85% of her PMS, DPK, AGO and cooking gas for her local use from which the government has consistently reduced its subsidy. This brings about high cost of production, consumption and investment consequently hampering economic growth.

A school of thought argues that Nigeria been the second largest exporter of crude oil in Africa, should be exempted from negative oil price shocks. This is not true in reality because windfalls from volatile oil price shocks are absorbed by the economy to expand the oil sector and those in power while the non-oil sector is malnourished in the form of high cost of production, distribution and consumption (Udoh and Egwaikhide, [20]). The emergence of Excess Crude Account in 2004 helped to cushion the effects of the drastic fall in oil prices during the global financial crisis of 2007-2009. However, successive governments could not sustain the Excess Crude Account as a result of reckless spending. This made the economy vulnerable to the recent oil price shock as decline in the global oil price caused steady rise in inflation rate (increase in average price of food), exchange rate depreciation and economic hardship on the populace. Why is fuel pump price in Nigeria on the increase, when global oil price was falling? This is a question, begging for an answer as the cost of food, transportation, education, health and other basic needs of life skyrocketed during this period (Ogboru et al. [21]).

The fig.2.1 below, shows the total refined and imported oil as evacuated and distributed by Pipelines and Petroleum Product Marketing Company (PPMC) between 2000 and 2016. The diagram shows that between year 2000 and 2008, the domestic demands for oil were met significantly by oil refined within the country on the average of 7million metric tonnes and complemented by imported oil on the average of 6million metric tonnes annually. However, there was a drastic fall in the local production of refined oil after 2008 from 7million metric tonnes on the average to 3million metric tonnes on the average and heavily complemented by imported oil on the average of 7million metric tonnes during these periods. This is as a result of the poor maintenance of the refineries and pipeline vandalism. Hence, Nigeria remains a net importer of fuel which makes her economy vulnerable to oil price shocks and exchange rate fluctuations (NNPC statistical bulletin [22]).

Fig. 2.1



Annual data of refined and imported oil evacuated and distributed by PPMC from 2000 t0 2016

Source: NNPC statistical bulletin

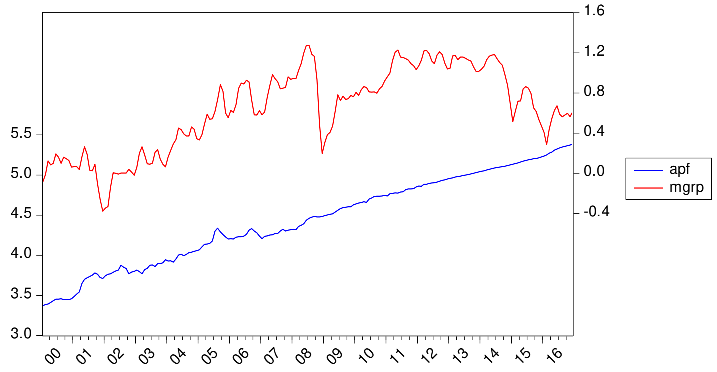
2.4 The Relationship Between Imported Price of PMS and Average Price of Food in Nigeria

PPMC defines the retail price of oil as the expected pump price of petroleum product at retail outlet. It is made up of landing cost of imported product plus reasonable distribution margins. The periods between 2000 and 2016 remain the most unpredictable periods of economic indices in the history of Nigeria. This era witnessed incessant fluctuation in the fuel pump price of petroleum, which affected every other sector of the economy, hence, translated into high cost of living.

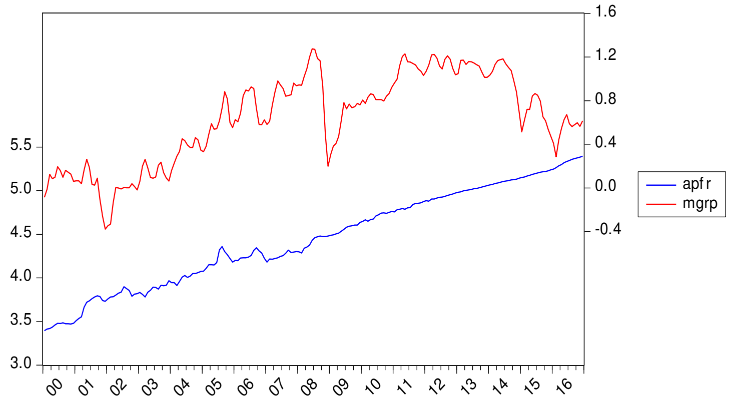
The figures below appear to suggest a positive co-movement between international price of PMS and average price of food in Nigeria. The graphs show that price of motor gasoline is highly volatile while the average price of food is less volatile but increasing in Nigeria. The persistent rise in the average price of food is attributable to global food crisis of 2008, exchange rate instability, oil price fluctuation, insurgency, herdsmen/farmers' crisis and the recent recession. On the other hand, the volatility of the oil price is attributable to the global financial crisis of 2008 as it shows a sharp decline during this period and subsequently shows high level of inconsistency due to exchange rate deprecation, the search for alternative sources of energy and the political games in the world oil markets which significantly affect the importation of refined motor gasoline in Nigeria. However, the research is saddled with the responsibility of evaluating the dynamic spillover effects of oil price volatility on the average price of food in Nigeria.

Fig. 2.2 The Relationship Between Oil Price and Prices of Food

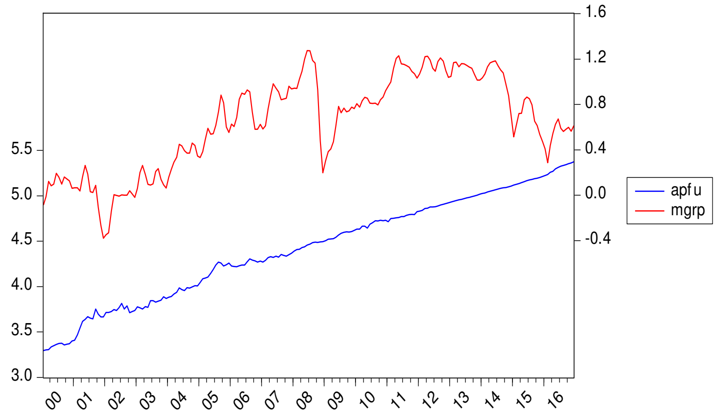
The relationship between natural log of imported price of PMS (MGRP) and natural log of average price of food (APF) in Nigeria 2000:M1 - 2016:M12



The relationship between natural log of imported price of PMS (MGRP) and natural log of rural average price of food in Nigeria 2000:M1 - 2016:M12



The relationship between natural log of imported price of PMS (MGRP) and natural log of urban average prie of food in Nigeria 2000:M1 - 2016:M12



Sources: CBN Statistical Bulletin (2016) and Energy Information Administration (EIA, 2018)

REVIEW OF RELEVANT LITERATURE

3.1 Concept and Measurement of Volatility or Shocks

This research paper is saddled with the responsibility of empirically analysing the relationship between oil price volatility spillover and prices of food in Nigeria. It will therefore, be inappropriate if we failed to comprehensively define volatility. Volatility measures the degree of variation of a variable with respect to time. The National Conference of Public Employee Retirement Systems (NCPERS) [23] defines economic volatility as radical swings commonly called "roller coaster" in the financial system and economy. They argue that it is a state of inconsistency as it brings about poor standard of living and inadequate planning in developed countries unlike economic stability. Kempthorne [24] referred to daily deviation of the change in price or value of a stock as volatility. This implies that volatility is measured by the daily percentage change in the price of commodity; hence, it is the degree of variation, not the level of prices.

Volatility does not take into consideration trend's direction, but its magnitude. This is because in the computation of variance all deviation from the mean is squared, so that the roles of signs become insignificant. Hence, the possibility of two different instruments with different volatilities having the same expected yields and the instrument with higher volatility having larger swings in values at the end of a given period of time may not be out of place.

3.2 Concept of Rural-Urban Cost of Living

It is often said, that one of the determinants of the standard of living of a given geographical area is the cost of living index of the area in question. Disparities have often been drawn along this line between rural and urban areas whose dwellers are believed to be characterised by low income and high income earnings respectively. Hence, rise in the general price level of goods and services have negative effect on their disposable income which reduces their standard of living.

Anafo and Naatu [25] argued that inflation is a determinant factor of standard of living which compels people to borrow and work extra at the expense of leisure for more income to finance their expenditure. The theories of dualism have also shed light on the dichotomy between rural and urban area. For example, Ravallion and Van de Walle [26] using spatial cost of living index explained that the presence of substantially higher average housing rents in urban areas than rural areas of dualistic developing countries, and higher average price of staple foods, have led to the assertion that the cost of living in the urban areas is a higher that of the rural areas.

3.3Transmission Mechanisms of Oil Price Shock

Lardic and Mignon [27] argued that there are six transmission mechanisms (Brown and Yucel, [28]; chuku, [1]):

1. Classic supply-side channel
2. Wealth transfer channel
3. Real balance channel
4. Inflationary channel
5. Demand side channel
6. Structural change channel

1. Classic supply-side effect is based on the argument that rising oil prices is an evidence of a negative disruption in the productive techniques within the economy, consequently leading to decline in the potential level of output. This implies rise in the average cost of production per unit of output which slows down the growth rate of output and profitability.

2. Increase in oil prices deflates the terms of trade of the importing countries, as wealth is been transferred from the importing countries to the exporting countries leading to fall in the purchasing of money of importing countries

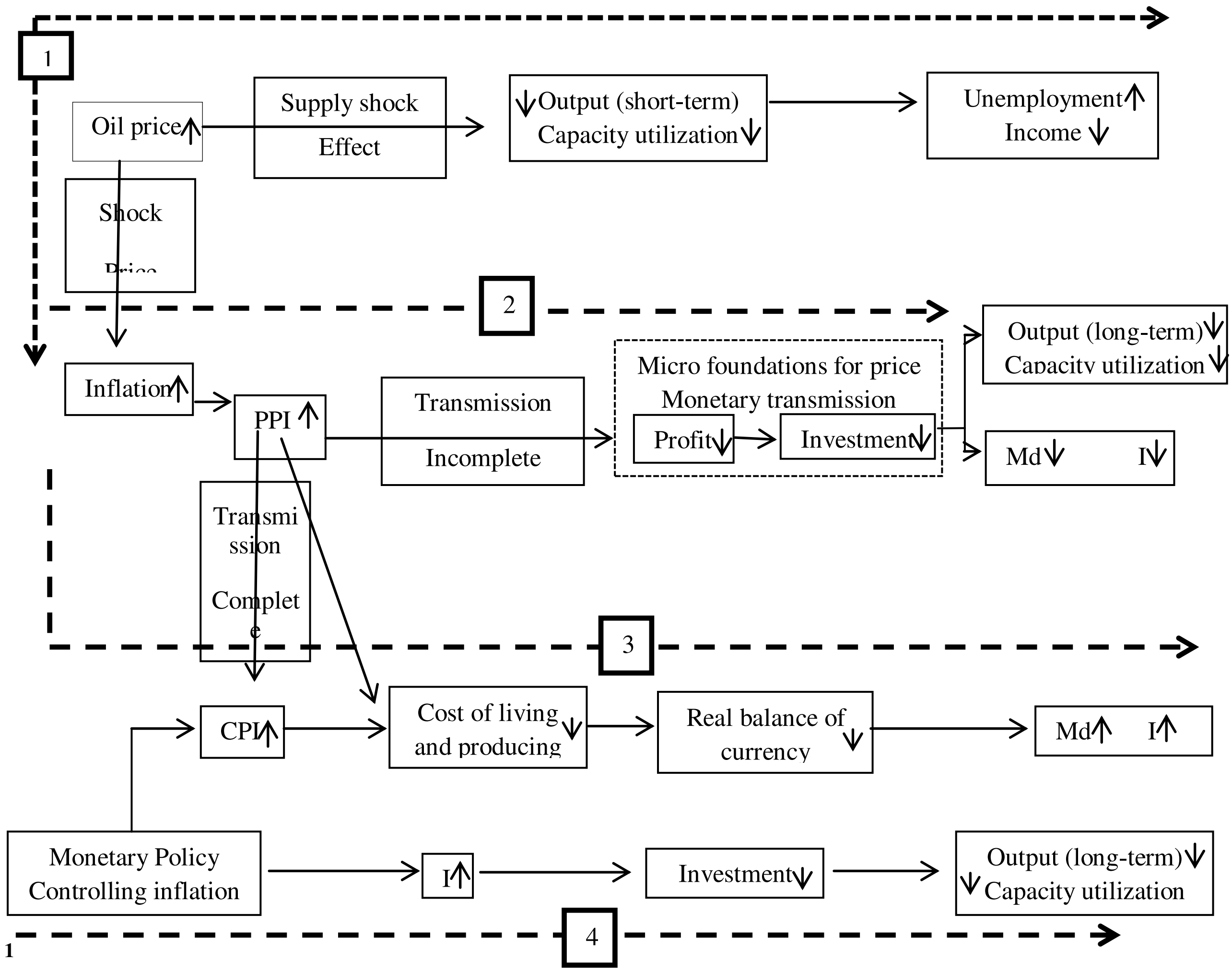
3. The real balance effect argues that a rise in oil prices will bring about a level of disequilibrium in the money market as the demand for money will rise and if not matched by increase in the money supply by monetary authority will lead to contractionary monetary policy which crowds out economic growth.

4. Inflationary effect is another transmission channel through which oil price increase affects the macroeconomic activities. This is an indirect effect (second round effect) as it could bring about price-wage loops.

5. Demand side effect implies that oil price increase could lead to fall in consumption, investment and stock prices. Oil prices spilling over to the cost of production of firms will to drop in investment consequently leading to fall in wages which reduces disposable income, hence, aggregate consumption.

6. If the rise in oil price is persistence, it could give rise to change in the production technique and have an impact on unemployment. A continuous rise in oil prices will cause a shift from oil intensive method of production to alternative means of production that are non-oil intensive. This implies reallocation of labour and capital within the economy capable of affecting unemployment if it persisted.

Fig. 3.0 Oil Price Shock Channel



1 Note: and imply increases and decreases respectively. Tang et al. [29] applied the diagram above to explain the workability of oil price transmission channels in China. They argue that an oil price shock that brings about increase in the marginal product of production resulting to fall in the level of output as a result of the decline in the capacity utilization is called is called supply side shock effect. This will bring about fall in income and increase in the rate of unemployment as shown by the dotted line *1*. However, quick recovery is possible in the short run for the supply side shock effect.

2 Oil price shock has long run effect on the level of output through monetary policy shock side effect. Oil price shock brings about increase in interest rate (I) which causes investment to fall as well as the level of output in the long run due to decline in capacity utilization. This is described be the dotted line 4.

3 The inflationary shock side effect is simply described by the dotted line 2. It shows that oil price shock breeds inflation as it increases producers' price index (PPI) consequently reducing profit and investment. This implies fall in the demand for money (Md) as well as interest rate (I) reducing the level of output in the long run.

3.4 Theoretical Review

The underlying theories of the effects of oil price volatility spillover on other macro-economic variables are built around its effects on these variables. These effects have been discussed mostly on two main strands, that is, the supply shock effects theory and demand shock effects theory. For example, Brown and Yucel [28] outlined four effects of oil price shocks:

1. Classic supply-side shock
2. Income transfer and aggregate demand shock
3. The real balance effect
4. Monetary policy

They explain that supply shock effect is a persistence rise in the prices of oil which is a major source of energy for production inputs. This slows down economic activities in the form of production and growth of output, consequently causing wage rate to fall and unemployment rate to rise accompanied by persistence rise in the general price level of goods and services (Lardic & Mignon, [27]; Chuku, [1]). Brown and Yucel [28] gave credence to the supply side effect above other effects acknowledged by them. They argue that:

> *of the explanations offered for the inverse relationship between oil price shocks and GDP growth, a classic supply-side shock best explains the facts. It can also explain the positive relationship between oil price shocks and measured increases in inflation. Taken alone, neither the real balance effect nor monetary policy can yield both slowing GDP growth and increased inflationary pressure. Income transfers can explain both phenomena only to the extent that monetary policy partially offsets the reduction in aggregate demand (North-Holland p 193-208).*

On the contrary, Kilian [30] opines that the supply shock effect is inefficient to explain the effect of change in crude oil prices on macro-economic activities. He explains that treating crude oil as a source of energy for factor inputs in value added productive activities is questionable. This is because imported crude oil in its raw state only enters the gross domestic products equation and not that of the domestic value added. He therefore, drums support for demand shock effect as a better explanation of oil price shocks for oil importing economies as it concerns retail energy price shocks and not crude oil price shocks. In the words of Hamilton [31]:

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4 Finally the increase in PPI is transmitted into an increase in consumer price index (CPI) in the form: decline in real demand for output. This reduces the real money balances of currency consequently increasing the demand for money (Md) and interest (I) rate as described by the dotted line 3.

> *a key mechanism whereby energy price shocks affect the economy is through a disruption in consumers' and firms' spending on goods and services other than energy(Elsevier p 363-398).*

Having acknowledged the efforts of researchers on the debate of the effects of oil price volatility on macroeconomic variables especially the supply shocks, Marquez [32] argues that they have their limitations, which include:

1. Repercussions of the increase in oil price on the rest of the world economic activities is a determinant factor of the effects of oil price rise on an economy which the supply shock has failed to acknowledge.
2. The inability to fully explain the effects of the significant portion of the world's income and trade attributable to higher oil prices for developing countries which is often been ignored by most theories.

To solve these problems, Marquez [32], divides the world economy into three country blocs: developed countries (DCs); oil producing countries, (OPEC); and non-OPEC developing countries, (LDCs). The countries were grouped according to their capacities to export manufactures, oil and primary products, respectively. He further addressed the following questions:

> -*to what extent is income in developed and less developed economies affected by oil-price changes? And how do these income effects feedbacks to OPEC's oil exports?*
> *-how successful is a restrictive fiscal policy in developed countries combating the inflationary impacts of an increase in the price of oil, and what are the repercussions for the rest of the world?*
> *-can a greater recycling of oil revenues by OPEC offset the adverse impacts of oil-price increases?*
> *What are the financial transfers to developing countries required to offset the adverse impacts of oil-price increases on economic growth?*
> *(North-Holland p 1-27).*

Below is the summary of his theoretical models:

Where *M* is import, *K* is capital, *L* is labour, *Y* is GDP, *P* is prices, *I* is investment, *B* is trade account, *G* is government purchase, *X* is exports, *A* is resource transfers, *C* is absorption, *1* is non-OPEC, d is DCs, o is oil, p is raw materials and m is manufactures.

Table3.0 Theoretical Model for a Three Region World Economy

Developed countries		
Income determination	$Y^d = C^d\left(Y^d\right) + G^d + B^d$	1
Balance of payments	$B^d = X^d_m - \left[(P_o/P_m)M^d_o + (P_p/P_m)M^d_p\right]$	2
Oil imports	$M^d_o = M^d_o(\frac{P_o}{P_m}, Y^d)$	3
Raw materials imports	$M^d_p = M^d_p(\frac{P_p}{P_m}, Y^d)$	4
Manufacture price	$P_m = \pi_o P_o + \pi_p P_p$	5
Non-OPEC developing countries		
Income determination	$Y^1 = f\left(K^1, \bar{L}^1\right)$	6
Capital stock	$K^1 = f\left(K^1_{-1} + I^1\right)$	7
Investment	$I^1 = i_o + iM^1_m$	8
Manufacture imports	$M^1_m = (A + P_p X^1_p - P_o M^1_o) / P_m$	9
Oil imports	$M^1_o = M^1_o\left(P_o/P_p, Y^1\right)$	10
OPEC		
Income determination	$Y^o = f\left(K^o\right)$	11
Capital stock	$K^o = K^o_{-1} + I^o$	12
Investment	$I^o = b_o + bM^o_m$	13
Manufacture imports	$M^o_m = \beta P_o X^o_o / P_m$	14
Equilibrium conditions		
Manufactures	$X^d_m = M^o_m + M^1_m$	15
Oil	$X^o_o = M^d_o + M^1_o$	16
Raw materials	$X^1_p = M^d_p \quad X^1_p = M^d_p$	17

Source: Marquez, J. (1986). Oil-price effects in theory and practice. ***Journal of Development Economics*****,** ***24*****(1), 1-27**

3.5 Empirical Review

The question of whether there is a co-movement between oil price volatility and food prices has been raised by different scholars. To answer this question, scholars through studies have mostly examined the long run and short run relationship, direction of causality and degree of volatility between oil price volatility spillover and price(s) of food.

Table 3.1 SUMMARY OF EMPIRICAL REVIEW

S/N	Author & Year	Country(s) & Scope	Methodology		Findings
			variables	Estimation methods	
[33]	Alghalith	Trinidad and Tobago (1974-2007)	Food price index, domestic price of crude oil	Non linear least squares regression	Higher oil price increases food price and higher oil price volatility yields a higher food price.
[20]	Udoh and Egwaikhide (2012)	Nigeria (1970-2008)	International oil prices, food inflation, money supply and nominal exchange rate	Cointegration test, causality test and VAR-GARCH model	No complementary relationship between oil price and food price inflation in Nigeria with a one way causality from oil price to domestic food price(s)
[34]	Kaltalioglu and Soytas (2011)	World (Jan. 1980-Apr. 2008)	Agricultural raw materials spot prices, food spot prices and oil spot prices	Cheung-Ng procedure and Causality test	Variations in oil prices do not granger cause food prices and absence of spillover from oil market to food market
[35]	Campiche et al. (2007)	World (2003-2007)	Oil prices, corn prices, sorghum prices, sugar prices, soybeans oil and palmoil prices	Johansen Co integration test	No relationship between oil prices and prices of agricultural commodities except for corn and soybean in the longrun
[36]	Arshad and Hameed (2009)	World (1980-2008)	Oil prices, prices of rice, maize and wheat	Johansen Co integration and Granger causality tests	There exists a long relationship between oil prices and food prices with a unidirectional causality from petroleum to cereal prices
[37]	Zhang et al. (2010)	World (1989-2008)	Oil price index, prices of maize, soybean, wheat, sugar and rice	Johansen Co integration test, Granger Causality test and VECM	A limited short run relationship between oil prices and food prices if any but no long run relationships
[38]	Natanelov et al. (2011)	World (Jul. 1989-Feb. 2010)	Crude oil price, prices of cocoa, rough rice, soybeans,	Johansen Co integration test and VECM	Developed commodity markets exhibit co-movement with crude oil in the long-run.

			soybean oil, wheat, corn, coffee, sugar, and gold		
[39]	Du and Hayes (2011)	World (Nov. 1998-Jan. 2009)	Crude oil prices and agricultural commodity prices	Bayesian analysis	Crude oil volatility spillover causes sharp changes in the agricultural markets especially in wheat and corn markets been sources of input for biofuels.
[40]	Gardebroek and Hernandez (2013)	World (1997-2011)	WTI, ethanol prices and corn prices	MGARCH model	No cross volatility effect from oil to corn markets.
[41]	Gogoi (2014)	World (1980-2011)	Oil price, prices of soybeans, maize and wheat.	Granger Causality and Cointegration tests	Oil prices and all prices of food except that of rice converge in the long run with a one way directional causality from oil prices to food prices.
[42]	Avalos (2014)	World (1986-2006)	Oil prices, prices of corn, soybeans, copper and gold.	VAR, VECM, Granger Causality, impulse response and structural break test	Short run relationship between oil prices and agricultural prices, slow long run relationship and unidirectional causality from agricultural prices to oil prices not the reverse
[43]	Kapusuzoglu and Ulusoy (2015)	World (Jan. 1990-May 2014).	Brent spot prices, WTI spot prices, prices of wheat, corn and soybeans	Johansen Cointegration test and Granger Causality test	No long run relationship between agricultural commodity prices and international oil prices with a unidirectional causality from oil prices to agricultural commodity prices.
[44]	Aye (2015)	South Africa (2002-2014)	Oil prices and CPI of food	VAR-BGARCH-in-mean model	Response of Food prices to positive and negative

					oil price shock is asymmetry.
[45]	Fowowe (2016)	South Africa (Jan. 2003-Jan. 2014)	Brent oil price, prices of soybeans, sunflower and maize	Non linear causality test and strucutural break cointegration test	No long run relationship between oil price and agricultural commodity prices. Food prices are indifferent to changes in global oil prices.
[46]	Nwoko et al. (2016)	Nigeria (2000-2013)	Oil price, prices of maize, rice, sorghum, soybeans and wheat	VAR, Johansen Cointegration and Granger Causality tests	Positive short run relationship between oil price and food prices except for rice and wheat prices and causality runs from oil price to prices of maize, soybeans and sorghum only.
[47]	Damba et al. (2017)	World (1990-2015)	Crude oil price returns, price index of red meat, food, diary, cereal, sugar and edible oil	BEKK and DVECH approach	Volatility between oil price returns and prices of food is low except in 2015 and a unidirectional spillover effect from oil price returns to price index of food
[48]	Nazlioglu and Soytas (2012)	World (Jan. 1980-Feb. 2010)	Prices 24 agirucultural commodities, exchange rate and oil price	Panel Cointegration and Causality analysis	Oil price changes have strong impact of agricultural commodity prices and weak dollar positively impacts agricultural commodity prices
[49]	Gozgor and Kablamaci (2014)	World (Jan. 1990-Jun. 2013)	27 agricultural commodity prices and oil price	Panel analysis	Increase in international oil prices bring about significant rise in agricultural commodity prices
[50]	Alom et al. (2011)	(Austrilia, New Zealand, South Korea, Singapore, Hong Kong, Taiwan, India and Thailand) (Jan. 1995-	Oil price and food price index	VAR, GARCH and Granger Causality test	Food prices in net food importing countries show stronger effects to shock in terms of mean

		Apr. 2010)			spillovers while volatility spillover remains indifferent in absorbing the oil price shocks between exporting and importing countries
[51]	Harri et al. (2009)	World (Jan. 1980-Sept. 2008)	Prices of petroleum, rice, maize, wheat and exchange rate	Johansen Cointegration test and ECM	All commodity prices except that of wheat converge in the long run with the price of oil.
[52]	Nazlioglu and Soytas (2011)	Turkey (Jan. 1994-March 2010)	Prices of crude oil, wheat, maize, cotton, soybeans, sunflower and exchange rate.	Toda-Yamamoto causality approach and Impulse Response Function analysis	Agricultural commodity prices do not significantly respond to oil price and exchange rate in the short run.
[53]	Wang et al. (2014)	World (Jan. 1980-Dec. 2012)	Brent oil price and prices of cocoa, soybean, barley, wheat, corn, cotton, rice, coffee and tea	Variance Decomposition and Johansen Cointegration tests with and without structural breaks	Agricultural commodity prices response to oil supply shocks is not significant but significant to aggregate demand shocks in pre-crisis periods but the reverse is the case in post-crisis periods
[54]	Al-Maadid et al. (2017)	World (2003-2015)	Prices of cocoa, coffee, corn, soybeans, sugar, wheat and crude oil.	VAR-GARCH model with structural breaks	Significant relationship between food and oil prices
[55]	Kumar (2017)	(Jan. 2006-Apr. 2015)	WTI and prices of wheat, corn, cotton, and soybeans	Rogers and Satchel range base volatility, Inclan and Tiao,s ICSS Algorithm and HAR	Evidence of significant volatility spillover from crude oil to agricultural commodity prices but this does not remain stable but exhibit multiple structural breaks using time varying volatility

					spillover.
[56]	Siami-Namini and Hudson (2017)	US (Jan. 1986-Nov. 2015)	Crude oil price volatility, exchange rate shock and 14 agricultural commodity prices	AR-EGARCH model, VAR-VECM and Granger causality approach	Oil price volatility and exchange rate shocks do not have significant impact of agricultural commodity prices in the short- run during pre-crisis period but the reverse is the case in the post-crisis periods

Research Design and Methodology

4.1 Research Methodology Design

In order to ensure that the results obtained from this study are valid, pre-tests and post-tests are performed on both the series and the model.

4.2 Model Specification

Kuotsoyiannis [57] defined model specification as the representation of the mathematical and economic relationships between the dependent and explanatory variables where they exist. Following Udoh and Egwaikhide [20], we adopt a modified multivariate model used for the analysis of the relationship between international oil price and domestic food prices. The functional form of the multivariate model is stated below:

$$FINF = F\left(OILVOL,\ NER\ and\ MS\right) \qquad (1)$$

Where *FINF* represents food inflation;

OILVOL represents oil price volatility;

NER represents nominal exchange rate; and

MS represents money supply

The modified version of this model which we will analyse is specified in a functional form below:

$$\mathbf{APF_i = F\left(RMGRPVOL,\ REXRVOL\right)} \qquad (2)$$

This can be written in econometrics form:

$$\mathbf{Log\left(apf\right) = \kappa_0 + \kappa_1 rmgrpvol + \kappa_2 rexrvol + \mu_{1t}} \qquad (3)$$

$$\mathbf{Log\left(apfu\right) = \Gamma_0 + \Gamma_1 rmgrpvol + \Gamma_2 rexrvol + \mu_{2t}} \qquad (4)$$

$$\mathbf{Log\left(apfr\right) = ¥_0 + ¥_1 rmgrpvol + ¥_1 rexrvol + \mu_{3t}} \qquad (5)$$

Where APF_i is a vector representing aggregate average price of food (APF), urban average price of food (APFU) and rural average price of food (APFR) which proxy food prices.

RMGRPVOL represents real mobile gasoline retail price volatility which proxy oil price volatility. We compute returns as $log\left(rmgrp_t / rmgrp_{t-1}\right)*100$.

REXRVOL represents real exchange returns volatility. We compute this as $log\left(rexr_t / rexr_{t-1}\right)*100$.

μ represents the residual term

Where κ_0 is the constant and $\kappa_{1,} \kappa_2$ represent the coefficients of the independent variables;

Γ_0 is the constant and Γ_1, Γ_2 represent the coefficients of the independent variables;

$¥_0$ is the constant and $¥_1$, $¥_2$ represent the coefficients of the independent variables.

The apriori expectation is that κ_1, Γ_1 and $¥_1$ will be greater than *0* while the apriori expectation of exchange rate remains indeterminate due to divergent opinions from strands of literature.

4.3 The Research Variables

The study adopts the required variables needed to achieve the set objectives. These variables include total average prices of food (APF), urban average prices of food (APFU), rural average prices of food (APFR), mobile gasoline retail prices (MGRP) and exchange rate (EXR). To suite the findings of the study, mobile gasoline retail prices is transformed into real mobile gasoline retail prices by dividing it with the consumer price index (CPI) before finding real mobile gasoline price (RMGRP) with the method used by Wang et al. [53].

Transforming the exchange rate into real exchange rate (REXR) helps to factor in the effect of change in prices over time. We achieve this by dividing the nominal exchange rate by consumer price index (CPI). To capture volatility spillover in oil prices and exchange rate, we adopt the GARCH (1, 1) as used by Udoh and Egwaikhide [20].

Prices of food denoted by aggregate average food prices (APF), urban average prices of food (APFU) and rural average prices of food (APFR) are the dependent variables while the independent variable is oil price volatility denoted by real mobile gasoline retail prices volatility (RMGRPVOL). For robustness of the model we adopt real exchange rate volatility (REXRVOL) as our control variable. We however take the natural log of the dependent variables to ensure uniformity of the variables.

4.4 Estimation Techniques

This research employs both descriptive and quantitative techniques of analysis. It must however, be stated that SVAR, TGARCH, PGARCH, EGARCH, ARIMA, MGARCH, ARFIMA, VAR-GARCH, ARCH, LA-VAR approaches have been used to explore the relationship between oil price shock and inflation in Nigeria (see ThankGod and

Maxwell [58]; Demachi [59]; Tule et al. [3]; Gershon and Nwokocha, [60]). In analysing the relationship between oil price volatility spillover and food prices Udoh and Egwaikhide [20] and Nwoko et al. [46] adopt the GARCH-VAR techniques. This study therefore, intends to build on the foundation laid by them to empirically analyse the spillover effects of oil price shock on the average prices of food in rural and urban areas of Nigeria using the General Autoregressive Conditional Heteroskedasticity-Todayamamoto (GARCH-VAR_{k+d}) (Nazlioglu and Soytas [52]; Udoh and Egwaikhide [20]).

4.4.1 Estimation of Volatility

The subject matter of this study is based on volatility spillover, it is therefore pertinent to compute the volatility for both real oil price returns and real exchange rate returns using the GARCH (1, 1) model as postulated by Bollerslev [61].

The GARCH (1, 1) model we adopt for the computation of volatility is shown below:

$$x_t = \omega_0 + \omega_1 x_{t-1} + \ldots + \omega_p x_{t-p} + \varepsilon_t \quad (6)$$

$$h_t = \varphi_0 + \varphi_1 \varepsilon_t^{\,2} + \varphi_2 h_{t-1} \quad (7)$$

Where x is a vector representing real oil price returns and real exchange rate returns, ε represents the residuals and h represents the conditional variance of the error. Equation 6 and 7 represent the mean equation and the variance equation respectively.

ω_0 is the constant in the mean equation and ω_1 represents the variables in question.

φ_0 is the constant in the variation equation

φ_1 and φ_2 are the coefficients of the ARCH and GARCH respectively.

4.4.2 VAR Estimation (Todayamamoto)

Brooks [62] argued that VAR became vocal after it was used by Sims [63]. He defined VAR as a system of regression which combines the univariate time series models and the simultaneous equations models. Bivariate VAR is the simplest form of VAR model as it contains only two variables. The values of these two variables are often determined by the various combinations of the t values of these variables and residuals. However, an extended version of the VAR model by Toda and Yamamoto [64] is to be adopted by this study.

The original VAR estimates are given below:

$$\log y_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \log y_{t-i} + \sum_{i=1}^{k} \varphi_{2i} x_{t-i} + \sum_{i=1}^{k} \lambda_{3i} z_{t-i} + \varepsilon_{1t} \quad 8$$

$$x_t = \theta_0 + \sum_{i=1}^{k} \theta_{1i} \log y_{t-i} + \sum_{i=1}^{k} \phi_{2i} x_{t-i} + \sum_{i=1}^{k} \gamma_{3i} z_{t-i} + \varepsilon_{2t} \quad 9$$

$$z_t = \vartheta_0 + \sum_{i=1}^{k} \vartheta_{1i} \log y_{t-i} + \sum_{i=1}^{k} \eta_{2i} x_{t-i} + \sum_{i=1}^{k} \sigma_{3i} z_{t-i} + \varepsilon_{3t} \quad 10$$

While Todayamamoto approach is given below:

$$\log y_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \log y_{t-i} + \sum_{j=k+1}^{k+d_{\max}} \alpha_{2i} \log y_{t-j} + \sum_{i=1}^{k} \varphi_{1i} x_{t-i} + \sum_{j=k+1}^{k+d_{\max}} \varphi_{2i} x_{t-j} + \sum_{i=1}^{k} \lambda_{1i} z_{t-i} + \sum_{j=k+1}^{k+d_{\max}} \lambda_{2j} z_{t-j} + \varepsilon_{1t} - 11$$

$$x_t = \theta_0 + \sum_{i=1}^{k} \theta_{1i} \log y_{t-i} + \sum_{j=k+1}^{k+d_{\max}} \theta_{2i} \log y_{t-j} + \sum_{i=1}^{k} \gamma_{1i} x_{t-i} + \sum_{j=k+1}^{k+d_{\max}} \gamma_{2i} x_{t-j} + \sum_{i=1}^{k} \phi_{1i} z_{t-i} + \sum_{j=k+1}^{k+d_{\max}} \phi_{2j} z_{t-j} + \varepsilon_{2t} ----12$$

$$z_t = \vartheta_0 + \sum_{i=1}^{k} \vartheta_{1i} \log y_{t-i} + \sum_{j=k+1}^{k+d_{\max}} \vartheta_{2i} \log y_{t-j} + \sum_{i=1}^{k} \delta_{1i} x_{t-i} + \sum_{j=k+1}^{k+d_{\max}} \delta_{2i} x_{t-j} + \sum_{i=1}^{k} \chi_{1i} z_{t-i} + \sum_{j=k+1}^{k+d_{\max}} \chi_{2j} z_{t-j} + \varepsilon_{3t} ---13$$

k is the optimal lag length, determined by the usual information criterion that is AIC and SIC.

d_{max} is the maximum order of integration

$\log y$ is a vector representing total average price of food (logapf),rural average price of food (logapfr) and urban average price of food (logapfu)

x represents real mobile gasoline retail price volatility (rmgrpvol)which proxy oil price volatility

z represents real exchange rate volatility (rexrvol)

ε represents innovations that may be contemporaneously correlated

Acknowledging the fact that time series data possess trends which result in spurious regression, the series shall be subjected to unit root tests.

This study adopts the Todayamamoto model because of its strengths. These strengths include ignoring the biasness posed by unit roots and cointegration tests. It does not require satisfying the properties of unit roots and cointegration as required under the original VAR and other multivariate model. The method postulates a modified level

VAR modelling, hence, causality testing with possibly cointegrating and integrating system (Zapata and Rambaldi [65]).

Despite its beautiful attributes, Todayamamoto model also has its shortcomings. These shortcomings include:

1. Toda and Yamamoto [64] explained that the approach suffers some loss of power, hence, it is inefficient. This is because of its origin (the VAR model), which is intentionally over-fitted.

2. Using Todayamamoto for small sample size may yield poor approximation of the asymptotic distribution of the t-test.

4.5 Pre-Test

4.5.1 Unit Root Test

In testing the validity of the result of a model, the test for stationarity is inevitable. The ability of a series to revert back to its mean is a good preliminary analysis that must be examined, for a series to be fit for use. This implies that, series must be free from unit root. Salisu et al. [66] argued that for a series to be fit for statistical analysis, it must possess the stationarity properties, that is, constant mean and variance, because:

1. Most time series models and techniques such as Vector Autoregressive (VAR), Autoregressive Moving Average (ARMA) process cannot be estimated with the presence of unit root, hence, pre-testing for unit roots is inevitable.

2. Pre-testing for unit roots in a series is very important as it helps to discover the presence of shocks. They argue that, shock on a series that is not stationary has permanent effects while it is transient on a series that is stationary.

3. For effective policy adjustment, cognisance must be given to the behaviour of a series to shocks. They explain that a series with a unit root makes designed policies to be more effective as it tend to alter the series from its long run path where no policy exists.

To ascertain the absence of unit root in the series, we employ the Augmented Dickey Fuller (ADF), PP and NGP unit root tests (Fedorova [67]). The ADF unit root test by Dickey and Fuller [68] tests the null hypothesis that a unit root is present in a time series sample while the alternative hypothesis is different depending on which version of the test is used, but it's usually stationary or trend stationary. The ADF is performed on level and first difference by estimating the following model:

No Constant and No Trend model:

$$\Delta y_t = \pi y_{t-1} + \sum_{i=1}^{k} \beta_1 \Delta y_t + \varepsilon_t \qquad 14$$

Constant and No Trend:

$$\Delta y_t = \alpha_0 + \pi y_{t-1} + \sum_{i=1}^{k} \beta_1 \Delta y_t + \varepsilon_t \qquad 15$$

Constant and Trend:

$$\Delta y_t = \alpha_0 + \alpha_1 t + \pi y_{t-1} + \sum_{i=1}^{k} \beta_1 \Delta y_t + \varepsilon_t \qquad 16$$

Where $\Delta y_t = y_t - y_{t-1}$ is the difference of the series y_t ; $\Delta y_{t-1} = y_{t-1} - y_{t-2}$ is the first difference of y_{t-1} etc. The coefficients are the parameters to be estimated while the lagged term is chosen by the Schwarz information criterion (SIC).

Phillips-Perrons unit root test (PP) by Phillips and Perrons [69] is employed to further validate the results of the ADF unit root tests. The PP test does not require the specification of serial correlation of the form Δy_t under the H_0. The PP ignores the condition of conditional homoscedasticity before it can be used as it helps to overcome the obstacle of mis-specified P of the AR order. This is often not overlooked by the ADF unit root tests.

Fedorova [67] explained that the PP unit root test is built on the ADF unit root test, however, the PP deviates from ADF as it states the test statistics *Z* for a model with constant as follows:

$$Z_\pi = T(\pi_T - 1) - \frac{1}{2}\frac{T^2 s_\pi^2}{s_T^2}(s_{LT}^2 - s_T^2) \qquad 17$$

$$Z_T = \left(\frac{s_T}{s_{LT}}\right) t_{DF} - \frac{1}{2}(s_{LT}^2 - s_T^2)\frac{1}{s_{LT}}\frac{Ts_{\hat{\pi}}}{s_T} \qquad 18$$

given that:

$$t_{DF} = \frac{\hat{\pi}_T - 1}{s_\pi}, \; s_T^2 = \frac{1}{T}\sum_{t=1}^{T}\hat{\varepsilon}_t^2, \; s_{LT}^2 = s_T^2 + 2\sum_{j=1}^{q}(1-\frac{j}{q+1})\hat{\gamma}_{j,T} \text{ and } \hat{\gamma}_{j,T} = \frac{1}{T}\sum_{t=j+1}^{T}\hat{\varepsilon}_t \; \hat{\varepsilon}_{t-j}$$

where t_{DF} represents the test statistics of *DF* test,

s_T^2 represents the OLS estimator of the non-systematic component variance

$\hat{\gamma}_{j,T}$ represents the maximum likelihood estimator of the non-systematic component covariance

q is a number of lag of covariance

We also employ Ng-Perron unit root test by Ng and Perron [70] which tests the null hypothesis that a unit root is present in a time series sample while the alternative hypothesis is different depending on which version of the test is used. Fedorova [67] argued that ADF and PP yields significantly very good results when the number of observation is very large but NGP yields better results. Since Ng-Perron unit root test is built on the ADF-GLS and PP unit root tests, we perform the test on level and first difference by estimating the following models:

$$MZ_\upsilon = (T^{-1}y_T^2 - s_{AR}^2)^{-1} \quad (19)$$

$$MSB = (T^{-1}\sum_{t=1}^{T} y_{t-1}^2 / s_{AR}^2)^{1/2} \quad (20)$$

$$MZ_t = MZ_\upsilon \times MSB \quad (21)$$

$$s_{AR}^2 = \hat{\varpi}_k^2 / (1-\hat{\beta}(1))^2 \quad (22)$$

4.5.2 Heteroscedasticity ARCH LM Tests

Homoskedasticity (implies same variance) is a central property of OLS estimate. Homoskedasticity describes a situation in which the error term is the same across all values of the independent variables. Heteroskedasticity (the violation of homoskedasticity) is present when the size of the error term differs across values of an independent variable. To test for the presence of heteroscedasticity, we estimate the following equations:

$$y_t = \omega + \sum_{i=1}^{q} p_i y_{t-i} + \varepsilon_t \quad (23)$$

Where y_t represents the high frequency series, that is, real oil price returns and real exchange rate returns. Equation 17 is regressed using Ordinary Least Squares to arrive at equation 18 below

$$\varepsilon_t^2 = \lambda + \sum_{j=1}^{p} \gamma_j \varepsilon_{t-j}^2 \qquad 24$$

We further regress equation 23 using OLS method. Our decision of likelihood of the presence of heteroscedasticity is guided by the following hypothesis:

$H_o = \gamma_1 = \gamma_2 = \gamma_3 ... \gamma_p = 0$ *that is there is no ARCH effect and* $H_1 = \gamma_1 \neq \gamma_2 \neq \gamma_3 ... \gamma_p \neq 0$ *that is there is ARCH effect.*

If H_0 is not rejected, then there is no presence of conditional heteroscedasticity for *ARCH* effect otherwise there is. The presence of *ARCH* effect implies volatility of y_t which must be captured when modelling the series.

4.6Post Estimation Tests

4.6.1 Autocorrelation LM Tests

Autocorrelation correlation is saddled with the responsibility of reporting the multivariate LM test statistics for residual series correlation up to the specified order. For lag order h, the test statistic is evaluated by running an auxiliary regression of the residuals U_t on the original right hand regressors and the lagged U_{t-h}, where the missing first h values of $U_{t-h}$are filled with zeros (Johansen, [71]). The hypothesis is set as:

$H_0 =$ *no autocorrelation and* $H_1 =$ *there is autocorrelation*

4.6.2The Impulse Response

The dynamic (lag) structure of the VAR transmits shock from the i-th variable not only to the variable in-question but also to all other endogenous variables. The effects of one time shock to one of the innovations on current and future values of the endogenous variables are traced by the response impulse. The effects of shocks on the adjustment path of the variables in the VAR model are revealed by impulse response function.

The impulse response equation could be derived from the generalized VAR model. Recall the generalized VAR model:

$$y_t = c + \psi_1 y_{t-1} + \psi_2 y_{t-2} + ... + \psi_p y_{t-p} + \varepsilon_t \qquad 25$$

This model can be rewritten as:

$$y_t = B^{-1}c + B^{-1}\varepsilon_t \qquad 26$$

Where $B = 1 - \psi_1 l - \psi_2 l^2 - ... - \psi_p l^p$

Equation 21 is usually used to trace the impulse response. It is regarded as the Vector Moving Average (*VMA*) model. The impulse response function can be deduced from the equation in-question by differentiating it with respect to each of the shocks $(\varepsilon_{it}, ...\varepsilon_{nt})$

4.6.3The Variance Decomposition

Beyond tracing the effects of a shock to one endogenous variable to the other in the VAR by impulse response, variance decomposition separates the variation in an endogenous variable into component shocks to the VAR. Hence, information is supplied by the variance decomposition on the relative importance of each random innovation in the variables of the VAR.

The contribution of each type of shock to the forecast error variance is measured by the Forecast Error Variance Decomposition. FEVD tells us the proportion of a change in a variable is attributable to its own shock and that attributable to other shocks. Salisu [72] argued that in the short run most variation on a variable is due to own shock which tend to decline in the long run while variations attributable to other shocks increase.

Salisu [72] explained that we can calculate the n-period forecast error of y_t as:

$$y_{t+n} - \varepsilon_t y_{t+1} = \psi_0 \varepsilon_{t+n} + \psi_1 \varepsilon_{t+n-1} + \psi_2 \varepsilon_{t+n-2} + ... + \psi_{n-1}\varepsilon_{t+1} = \sum_{i=0}^{n-1} \psi_0 \varepsilon_{t+n-1} \qquad 27$$

4.7 Types and Sources of Data

Since this study is saddled with the responsibility of analysing the oil price volatility spillover effects on the average food prices in Nigeria over time, it disaggregates average food prices into rural food prices and urban food prices. Hence, secondary data is sourced for retail mobile gasoline prices, average food prices, average urban food prices and average rural food prices for this analysis. Data for the average food prices is obtained from CBN statistical bulletin [73] and that of retail mobile gasoline price is obtained from U.S Energy Information Administration [74].

Baumeister and Kilian [75] opined that oil price and agricultural commodity prices fundamentally changed after May 2006. Joining this argument, Wang et al. [53] explain that oil shocks have minimal effect on agricultural commodity prices in pre-crisis periods, while it is higher in post-crisis period. Corroborating this argument, Siami-Namini and Hudson [56] argue that prices of food do not significantly react to oil price volatility spillover in pre-crisis period but do in and post-crisis period. Hence, our study employs monthly data spanning from January 2000 to December 2016 dividing the periods into pre-crisis (from January, 2000 to April, 2006) and post-crisis (from May, 2006 to December, 2016).

ANALYSIS

5.1 Descriptive Data Analysis

We subject the variables used for this study to proper scrutiny by performing a descriptive analysis on the data. Since, the study is concerned with evaluating oil price volatility spillover effects on the average prices of food in the pre-crisis periods and the post-crisis periods, descriptive analysis is performed for the whole sample as well as the two subsamples, that is, pre-crisis periods and post-crisis periods. The study finds out that the mean prices of most commodities in the post-crisis periods outweigh that of the pre-crisis periods and the full sample.

The study also discovers that real exchange rate volatility and real oil price volatility are highly volatile for second period as the standard deviation for real exchange rate increases greatly and that of oil price declines heavily in the post-crisis periods. On the other hand, the prices of food both in the rural and urban areas as well as total prices of food reveal low volatility in the post-crisis periods with increased standard deviation but low.

In the post-crisis periods the maximum of all the variables are on the increase compared to that of the pre-crisis periods though similar to that of the full sample. A conspicuous increase during this period is the real exchange rate returns volatility. On the other hand, the minimum of the variables in the post-crisis periods also rises relative to the pre-crisis periods except for that of the real mobile gasoline retail price returns volatility which shows a decrease. It must be noted that the minimum of the variables in the pre-crisis periods possesses the same attributes with that of the full sample except for that of real mobile gasoline retail price returns volatility which is an increase away from that of the full sample.

The Jarque-Bera statistics by Jarque and Bera [76] shows that the variables in the pre-crisis periods are normally distributed as we accept the null hypothesis of normal distribution at *5%* level of significance while variables in the post-crisis periods and full sample are not normally distributed, hence, we reject the null hypothesis of normal distribution at the same level of significance using the p-values. These are shown in table 5.0.

Table 5.0 Descriptive statistics of commodity prices (logarithmically)

	Log(apf)	Log(Apfr)	Log(apfu)	rexrvol	rmgrpvol
Sub-Sample (Pre-crisis period)					
Mean	3.853	3.868	3.809	-0.001	-2.590.
Std. Dev	0.255	0.249	0.276	2.224	7.778
Max	4.337	4.359	4.272	4.952	19.150
Min	3.388	3.413	3.304	-6.240	-21.657
Skewness	-0.108	-0.114	-0.110	0.046	-0.204
Kurtosis	2.246	2.276	2.240	3.015	3.177
Jarque-Bera	1.919	1.801	1.957	0.027	0.565
Sub-Sample (Post-crisis period)					
Mean	4.790	4.798	4.786	-0.666	0.333
Std. Dev	0.336	0.348	0.318	3.958	7.544
Max	5.374	5.385	5.362	28.645	22.073
Min	4.206	4.182	4.239	-0.853	-35.626
Skewness	-0.129	-0.182	-0.027	4.055	-0.610
Kurtosis	1.855	1.838	1.881	25.022	6.634
Jarque-Bera	7.239**	7.788**	6.586**	2891.183***	77.148***
Full sample					
Mean	4.439	4.450	4.421	0.326	-0.275
Std. Dev	0.548	0.548	0.561	3.361	7.625
Max	5.374	5.385	5.362	27.567	21.137
Min	3.388	3.413	3.304	-8.009	-36.397
Skewness	-0.123	-0.085	-0.221	3.832	-0.507
Kurtosis	1.902	1.865	1.977	27.452	5.327
Jarque-Bera	10.648**	11.082**	10.439**	5526.902***	54.231***

Source: Computed by the Author
Notes: The Jarque-Bera [76] *statistic tests for the null hypothesis of Gaussian distribution *, ** and *** denote rejection of the null hypothesis at 10%, 5% and 1% significance levels, respectively.*

5.2 Unit Root Tests

The results of unit root tests are provided in tables 5.1and 5.2 according to Augmented Dickey Fuller's and Phillips-Perron's null hypothesis of the existence of unit root in a time series. We employ the Schwarz information criterion (SIC) to determine the optimal lag for ADF and Newey-West Bandwidth to determine the optimal lag for PP. The two methods reveal similar results with a great disparity among the full sample, pre-crisis periods and post-crisis periods in terms of the absence of unit root in the series.

The methods show that the aggregate price of food (APF) and average price of food in rural areas (APFR) rejects the null hypothesis of the presence of unit root at level at 5% level of significance respectively in both the full sample and the post-crisis periods and at first difference at 1% level of significance in the post-crisis periods for the two variables. Both ADF and PP reveal that the urban average price of food (APFU) and the independent variables (RMGRP and REXR) reject the null hypothesis of presence of unit root at level at 10% level of significance and at first difference at 1% level of significance respectively in full sample and post-crisis periods. Aggregate price of food (APF), rural average price of food (APFR) and urban average price of food (APFU) reject the null hypothesis at first difference at 1% level of significance while the independent variables reject the null hypothesis at level at 1% level of significance in the pre-crisis period for both methods.

Table 5.3 shows that the NGP unit root test agrees with the two methods used above as its results show that real oil price volatility and real exchange rate volatility reject the null hypothesis at level at 1% level of significance throughout the periods respectively. On the other hand, NGP shows a slight deviation from the results of ADF and PP for the dependent variables. For example, in the full sample period APF and APFU reject the null hypothesis at first difference at 1% level of significance and APFR rejects the null hypothesis at level at 5% level of significance. APF and APFR reject the null hypothesis at level at 10% level of significance while APFU rejects the null hypothesis at first difference at 1% level of significance in the pre-crisis period. Finally, in the post-crisis period APF rejects the null hypothesis at first difference at 1% level of significance while APFR and APFU reject the null hypothesis at level at 10% level of significance.

5.3 Heteroskedasticity Tests

5.3.1 Testing for the Presence of ARCH effect in Real Mobile Gasoline Retail Price (RMGRP)

Table 5.4 below explains the test statistics for the presence of ARCH effects in the variable. The RMGRP shows evidence of ARCH effects as revealed by the results of the F-test up to 5 lags for the full sample and post-crisis periods but absence for the pre-crisis periods. At 1 and 5 percent level of significance, the test statistics at all the chosen lags for the full sample and post-crisis periods are statistically significance resoundingly rejecting the "no ARCH" hypothesis. This conforms to the results described under the summary statistics in table 5.0.

5.3.2 Testing for the Presence of ARCH effect in Real Exchange Rate (REXR)

Table 5.5 further validates the findings in table 5.0 in describing the properties of real exchange rate through the ARCH effects test. The REXR shows evidence of ARCH effects as revealed by the results of the F-test up to 5 lags for the full sample and post-crisis periods but absence for the pre-crisis periods. At 1 and 5 percent level of significance, the test statistics at all the chosen lags for the full sample and post-crisis periods are statistically significant validating the rejection of the "no ARCH" hypothesis. This conforms to the results described under the summary statistics in table 5.0.

Table 5.1: Results of unit root tests as revealed by ADF

ADF							
VARIABLE	Level			First Difference			1(d)
Full sample							
	Non	Constant	Constant and Trend	Non	Constant	Constant and Trend	
Log(apf)	4.544	-0.877	-0.877**	-9.191***	-10.749***	-10.758***	I(0)
Log(apfr)	4.209	-4.179**	-0.798	-9.938***	-11.240***	-11.256***	I(0)
Log(apfu)	6.850	-3.1535*	-1.3285	-1.5168	-15.0701***	-15.0250***	I(0)
Rrmgrpvol	-11.376***	--11.351***	--11.375***	-9.756***	-9.704***	-9.730***	I(0)
Rrexrvol	-8.999***	-9.206***	-8.957***	-9.417***	-9.356***	-9.401***	I(0)
Pre-crisis period							
Log(apf)	2.228	-1.097	-2.929	-5.802***	-6.406***	-6.387***	I(1)
Log(apfr)	2.833	-1.120	-3.073	-6.255***	-6.749***	-6.726***	I(1)
Log(apfu)	3.396	-0.987	-2.287	-7.839***	-9.044***	-9.021***	I(1)
Rrmgrpvol	-7.760***	-7.704***	-7.812***	-7.595***	-7.547***	-7.490***	I(0)
Rrexrvol	-8.478***	-8.420***	-8.397***	-10.102***	-10.028***	-9.961***	I(0)
Post-crisis period							
Log(apf)	8.270	0.263	-2.189	-1.780*	-8.775***	-8.752***	I(1)
Log(apfr)	6.837	0.060	-2.166	-0.294	-7.755***	-7.652***	I(1)
Log(apfu)	9.799	0.430	-2.909	-1.376	-12.217***	-12.194***	I(1)
Rrmgrpvol	-9.384***	-9.363***	-9.327***	-10.807***	-10.766***	-10.722***	I(0)
Rrexrvol	-7.090***	-7.272***	-7.472***	-11.272***	-11.226***	-11.181***	I(0)

Source: Computed by the Author
Note: ADF denotes the statistics of Augmented Dickey-Fuller [68] *unit root test. The optimal lag length test is chosen based on Schwarz information criterion (SIC). *, **, *** denote rejection of the null hypothesis at 10%, 5% and 1% significance levels, respectively.*

Table 5.2 Results of unit root tests as revealed by Phillips-Perron

PP							
VARIABLE	Level			First Difference			1(d)
Full sample							
	Non	Constant	Constant and Trend	Non	Constant	Constant and Trend	
Log(apf)	5.075	-0.896	-4.071**	-9.191***	-10.799***	-10.755***	I(0)
Log(apfr)	4.594	-0.836	-4.181**	-9.938***	-11.302***	-11.248***	I(0)
Log(apfu)	6.850	-1.282	-3.186*	-38.090***	-15.024***	-15.067***	I(0)
Rmgrpvol	-12.907***	-35.303***	-12.517***	-334.044***	-374.462***	-184.973***	I(0)
Rexrvol	-9.280***	-9.321***	-9.531***	-31.972***	-72.587***	-15.307***	I(0)
Pre-crisis period							
Log(apf)	2.449	-1.149	-3.029	-31.277***	-31.589***	-31.172***	I(1)
Log(apfr)	2.676	-1.141	-2.601	-6.165***	-6.552***	-6.521***	I(1)
Log(apfu)	3.503	-0.988	-2.327	-7.918***	-9.044***	-9.021***	I(1)
Rmgrpvol	-8.465***	-8.409***	-12.159***	-7.595***	-7.547***	-7.490***	I(0)
Rexrvol	-8.478***	-8.420***	-8.398***	-35.467***	-35.133***	-35.004***	I(0)
Post-crisis period							
Log(apf)	7.771	0.220	-2.609	-6.509***	-8.559***	-8.493***	I(1)
Log(apfr)	6.224	0.008	-2.567	-7.207***	-8.733***	-8.695***	I(1)
Log(apfu)	14.462	0.777	-2.904	-8.516***	-13.044***	-13.152***	I(1)
Rmgrpvol	-9.245***	-9.219***	-9.227***	-54.902***	-54.647***	-54.251***	I(0)
Rexrvol	-5.298***	-5.232***	-5.099***	-28.448***	-28.916***	-29.528***	I(0)

Source: Computed by the Author
Note: PP denotes the statistics of Phillips-Perrons[69] *unit root test. The optimal lag length test is chosen based on Newey-West Bandwidth.. *, **, *** denote rejection of the null hypothesis at 10%, 5% and 1% significance levels, respectively.*

Table 5.3 Results of unit root tests as revealed by NG and Perron

NGP					
VARIALE	Level		First difference		1(d)
Full sample					
	Constant	Constant and Trend	Constant	Constant and Trend	
Log(apf)	1.531	-14.508	-91.737***	-93.616***	I(1)
Log(apfr)	1.523	-18.560**	-93.807***	-95.624***	I(0)
Log(apfu)	1.535	-5.350	-100.661***	-100.656***	I(1)
rmgrpvol	-1.046	-89.108***	0.922	--0.253	I(0)
rexrvol	-119.495***	-120.739***	-0.849	-151.579***	I(0)
Pre-crisis period					
Log(apf)	1.005	-16.489*	-34.153***	-34.296***	I(0)
Log(apfr)	0.892	-17.870*	-35.033***	-35.177***	I(0)
Log(apfu)	1.397	-8.869	-36.872***	-36.848***	I(1)
rmgrpvol	-29.933***	-34.634***	-0.185	0.358	I(0)
rexrvol	-36.912***	-36.992***	-33.327***	-30.481***	I(0)
Post-crisis period					
Log(apf)	1.774	-8.184	-59.465***	-59.578***	I(1)
Log(apfr)	-7.144*	-7.799	-23.275***	-24.520***	I(0)
Log(apfu)	1.949	-16.710*	-47.538***	-62.846***	I(0)
rmgrpvol	-59.344***	-60.475***	-1.373	-58.784***	I(0)
rexrvol	-73.368***	-89.503***	-98.883***	-121.689***	I(0)

Source: Computed by the Author

Note: NGP denotes the statistics of Ng-Perrons [70] *unit root test. The optimal lag length test is chosen based on Schwarz information criterion (SIC) (Schwarz, 1978). *, **, *** denote rejection of the null hypothesis at 10%, 5% and 1% significance levels, respectively. The decision rule for the ng-perrons unit root test similar to that of ADF*

Table 5.4 Results for ARCH Effects in RMGRP

Model	Period	$p=1$		$p=5$	
		F-test	**Std. Error**	**F-test**	**Std. Error**
	Full Sample	7.0164	116.78**	2.9346	116.72**
K=1	Pre-crisis	0.6565	88.02	0.9518	89.91
	Post-crisis	4.6620	129.45**	2.8435	127.46**
	Full Sample	50.4456	150.73**	11.9011	150.27***
K=2	Pre-crisis	0.0319	88.68	1.1147	89.54
	Post-crisis	35.5944	169.99***	8.0459	170.60***
	Full Sample	46.4791	157.17***	11.1935	156.63***
K=3	Pre-crisis	0.0090	96.17	0.9796	98.15
	Post-crisis	38.2823	176.84***	9.4105	176.18***

Source: Computed by the Author
*Note: the table follows the mean equation in equation 6 (AR model). K and p represent the order of integration and lag length respectively. ***= 1% and **=5% level of significance*

Table 5.5 Results for ARCH Effects in REXR

Model	Period	$p=1$		$p=5$	
		F-test	**Std. Error**	**F-test**	**Std. Error**
	Full Sample	52.2332	28.59***	15.2933	27.67***
K=1	Pre-crisis	0.0445	7.0556	0.4268	6.9289
	Post-crisis	40.1478	33.00***	12.7447	31.51***
	Full Sample	26.3980	41.53***	6.0567	41.90***
K=2	Pre-crisis	0.0396	7.1050	0.6654	6.9277
	Post-crisis	15.8292	51.1591***	3.5551	52.29**
	Full Sample	26.3243	41.37***	6.0918	41.73***
K=3	Pre-crisis	0.0695	7.1488	0.5963	7.0065
	Post-crisis	15.3992	50.94***	3.4761	52.08**

Source: Computed by the Author
*Note: the table follows the mean equation in equation 6 (AR model). k and p represent the order of integration and lag length respectively. ***= 1% and **=5% level of significance.*

5.4 Volatility Measurement

Tables 5.4 and 5.5 show the presence of ARCH effects for the full sample and the post-crisis periods but absent in the pre-crisis era. This implies that real exchange rate returns and real mobile gasoline retail price returns are volatile for the full sample and the post-crisis periods while they are not in the pre-crisis periods due to the absence of ARCH effects. Hence, we proceed with the measurement of volatility using $GARCH\ (p,q)$ with $p,q=1$ by estimating equation 6.

Table 5.6 made up of panel A to C displays the results of volatility for the different periods. The coefficients of ARCH (φ_1) and GARCH (φ_2) effects are statistically significant for the full sample and post-crisis periods in panel A and B respectively at different levels of significance. Pre-crisis period in panel C reveals ARCH and GARCH with coefficients that is insignificant, given their p-values. The results in table 5.4 is in tandem with previous results obtained, claiming that real exchange rate returns and real mobile gasoline retail price returns are not volatile in the pre-crisis period but highly volatile in full sample and post-crisis periods.

5.4.1 Persistence of Shocks

Under the persistence of shocks, two major issues are of paramount importance: the issue of stationarity which implies that if the sum of the coefficients of both ARCH and GARCH effects is less than 1 then the model in question can be described as a stationary GARCH model and therefore valid for interpretation. Hence, persistence of shocks exists. These shocks can however, be temporary or permanent shocks in mean reversion.

If $|\sum \varphi_1 + \varphi_2| \to 0$, then the level of persistence is assumed weak and has faster mean reversion

If $|\sum \varphi_1 + \varphi_2| \to 1$, then the level of persistence is assumed high and has slower mean reversion

If $|\sum \varphi_1 + \varphi_2| \approx 1$, this implies an integrated ARCH which is non-stationary.

5.4.1.1 Full Sample

For shocks on real exchange rate returns and real mobile gasoline retail price returns to be persistence in the full sample the coefficients for the ARCH and GARCH must be less than one. In panel A of table5.4 the sums of real exchange rate (REXR) and that of real mobile gasoline retail price (RMGRP) are *3.3941* and *0.7969*. This implies that the GARCH effect for RMGRP is stationary and that its shocks have high level of persistence and slows at reverting to the mean (Salisu and Fasanya [77]). On the other hand, the GARCH effect for REXR is not stationary.

5.4.1.2 Pre-Crisis

Panel B of table 5.4 shows that for real oil price (RMGRP) and real exchange rate (REXR), the persistence of volatility in the pre-crisis period is weak and faster at reverting to the mean. This is because the sums of their ARCH and GARCH effects are *0.1194* and *0.4299* which tend towards zero. However, volatility of the real oil price returns and real exchange rate returns is insignificant as against the assumption of Salisu and Fasanya [77].

5.4.1.3 Post-Crisis

In panel C the sums of the coefficients for ARCH and GARCH effect of REXR and RMGRP are *4.9796* and *0.7022*. This implies that the GARCH effect for (RMGRP) is stationary and that it shocks have high level of persistence and slow at reverting to the mean during this period. On the other hand, the GARCH effect for REXR is not stationary.

5.4.2 Impact of Shock

The impact of shocks is either permanent or temporary. If $|\sum \varphi_1 + \varphi_2| \approx 1$, then the impact of shock is permanent and if $|\sum \varphi_1 + \varphi_2| < 1$, we say that the impact of the shock is temporary.

5.4.2.1 Full Sample

In panel A the sums of the coefficients for ARCH and GARCH effects of REXR and RMGRP are *3.3941* and *0.7969* respectively. This implies that the GARCH effect for RMGRP is stationary and that its shocks have temporary impact. On the other hand, the GARCH effect for REXR is not stationary and its impact is permanent.

5.4.2.2 Pre-Crisis

Panel B of table 5.6 shows that in the pre-crisis period, the impact of shocks for both oil price (RMGRP) and real exchange rate (REXR) is temporary and stationary with values *0.1194* and *0.4299.*This implies that they fade off over time.

5.4.2.3 Post-Crisis

In panel C the sums of the coefficients for ARCH and GARCH effects of REXR and RMGRP are *4.9796* and *0.7022* respectively. This implies that the GARCH effect for RMGRP is stationary and that its shocks have temporary impact. On the other hand, the GARCH effect for REXR is not stationary and its shock is permanent.

Table 5.6 Results for GARCH (1, 1) model estimation

Panel A

Full Sample

Parameter	Coefficient (Std. Error)	parameter	Coefficient (Std. Error)
Mean Equation		Mean Equation	
Constant	-0.1485 (0.7664)	Constant	-0.8628(0.0340)
rmgrp	0.3701(0.0693)***	rexr	-0.2727(0.0478)***
Variance Equation		Variance Equation	
Constant	11.9819(7.1279)*	Constant	0.0079(0.0112)
φ_1	0.2090 (0.0593)***	φ_1	3.2372(0.3522)***
φ_2	0.5879 (0.1382)***	φ_2	0.1569(0.0225)***

Panel B

Pre-Crisis

Parameter	Coefficient (Std. Error)	parameter	Coefficient (Std. Error)
Mean Equation		Mean Equation	
Constant	-0.0614(1.0178)	Constant	-0.7657(0.2784)
rmgrp	0.3278(0.1256)**	rexr	0.0923(0.1340)
Variance Equation		Variance Equation	
Constant	66.8679(99.4175)	Constant	3.1212(15.7290)
φ_1	-0.0879(0.1866)	φ_1	-0.0328(0.1253)
φ_2	-0.0315(1.5945)	φ_2	0.3971(3.1157)

Panel C

Post-Crisis

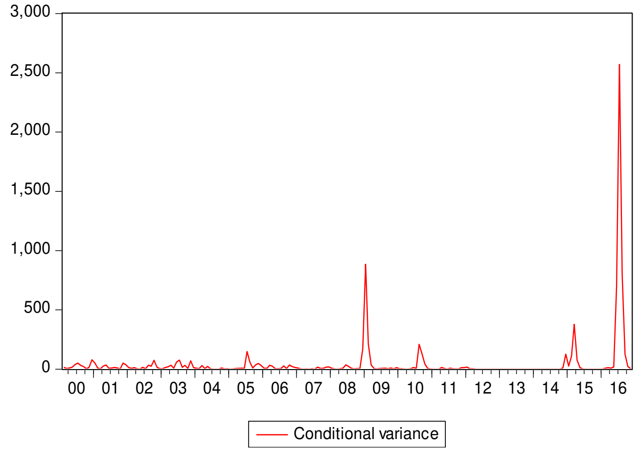
Parameter	Coefficient (Std. Error)	parameter	Coefficient (Std. Error)
Mean Equation		Mean Equation	
Constant	-0.3057(0.6588)	Constant	-0.9005(0.0219)***
rmgrp	0.3969(0.0813)***	rexr	-0.3442(0.0254)***
Variance Equation		Variance Equation	
Constant	16.4422(11.7868)	Constant	0.0585(0.0220)**
φ_1	0.3046(0.1010)**	φ_1	4.9789(0.6369)***
φ_2	0.3976(0.2641)**	φ_2	0.0007(0.0059)*

Note: *, **, *** denote 10%, 5%, 1% levels of significance respectively. While the coefficient remains as defined in chapter 4

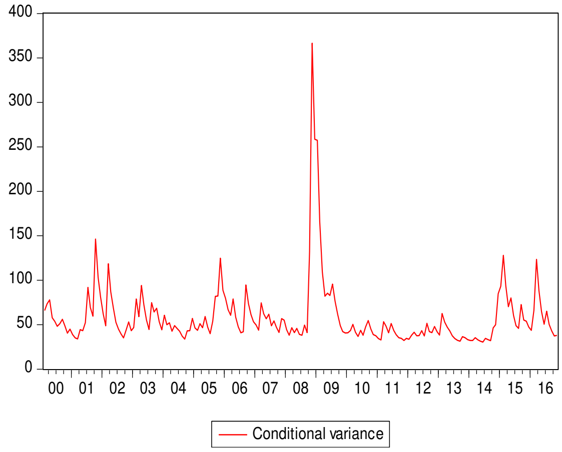
Fig. 5.0 Graphs of Conditional Variance for the Differing Periods

Panel A1: Full sample

real exchange rate returns volatility

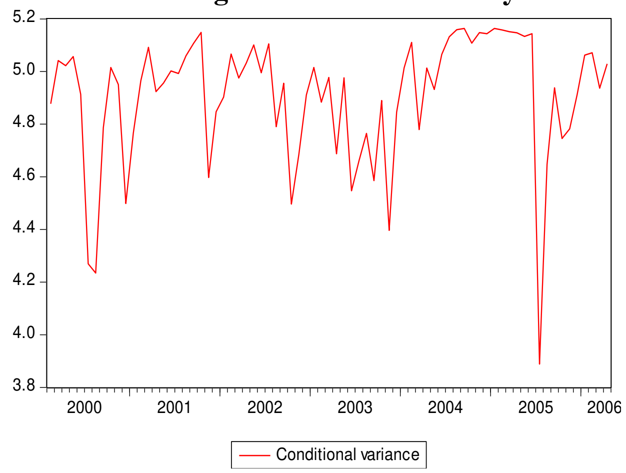


real oil price returns volatility

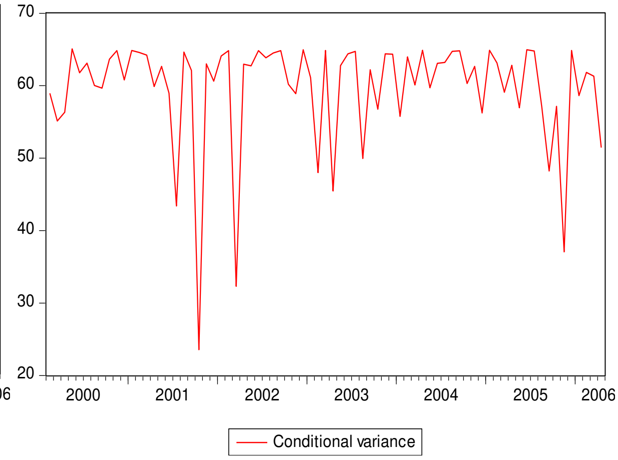


Panel B1: Pre-crisis

real exchange rate returns volatility

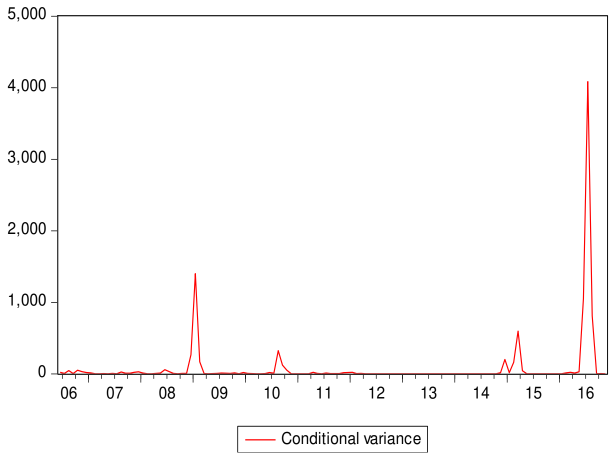


real oil price returns volatility

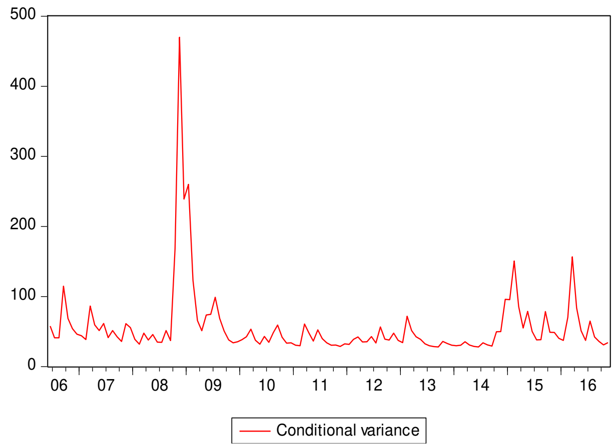


Panel C1: Post-crisis period

real exchange rate returns volatility



real oil price returns volatility



5.5 Autocorrelation LM Tests

One of the conditions for validating a model is the autocorrelation test. The autocorrelation for the estimated Todayamamoto model is given in table 5.7. This shows the absence of autocorrelation in all the equations.

Table 5.7 Result of Autocorrelation LM Test

	Full sample			**Pre-crisis**			**Post-crisis**		
	Lags	LM-Stat	Prob	Lags	LM-Stat	Prob	Lags	LM-Stat	Prob
Log(apf)	10	4.5250	0.874	10	5.0610	0.829	10	5.4509	0.793
Log(apfr)	10	5.8951	0.750	10	4.7660	0.854	10	7.1294	0.624
Log(apfu)	10	8.5020	0.485	10	13.0530	0.160	10	4.7784	0.853

Source: Computed by Author
Note: that when the p-value is greater than the level of significance that is 5% we accept the null hypothesis of no autocorrelation.

Figure 5.1 Time Series of Residuals of Estimated Todayamamotomodel for Full Sample

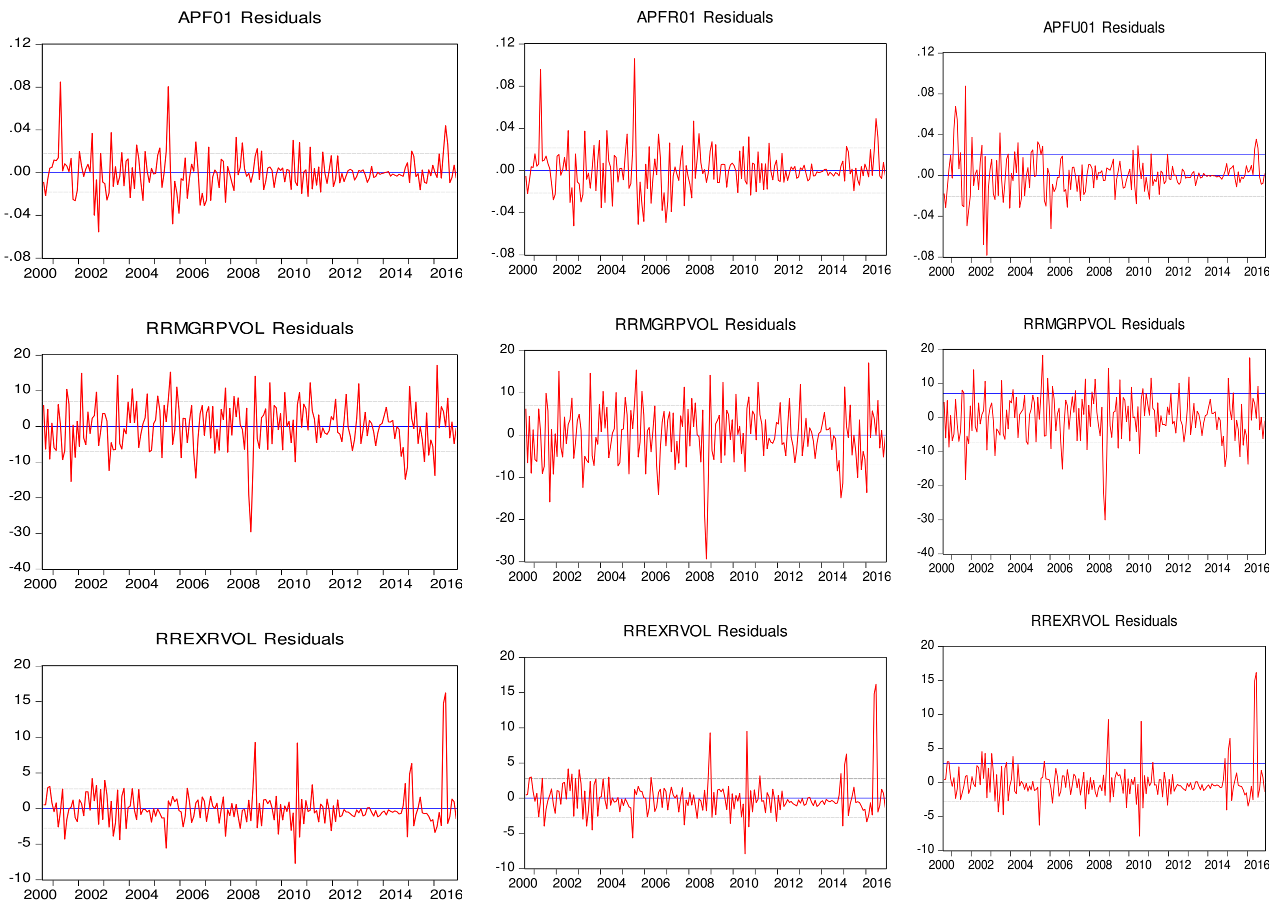


Fig. 5.2 Time series of Residuals of Estimated Todayamamoto model for Pre-crisis Periods

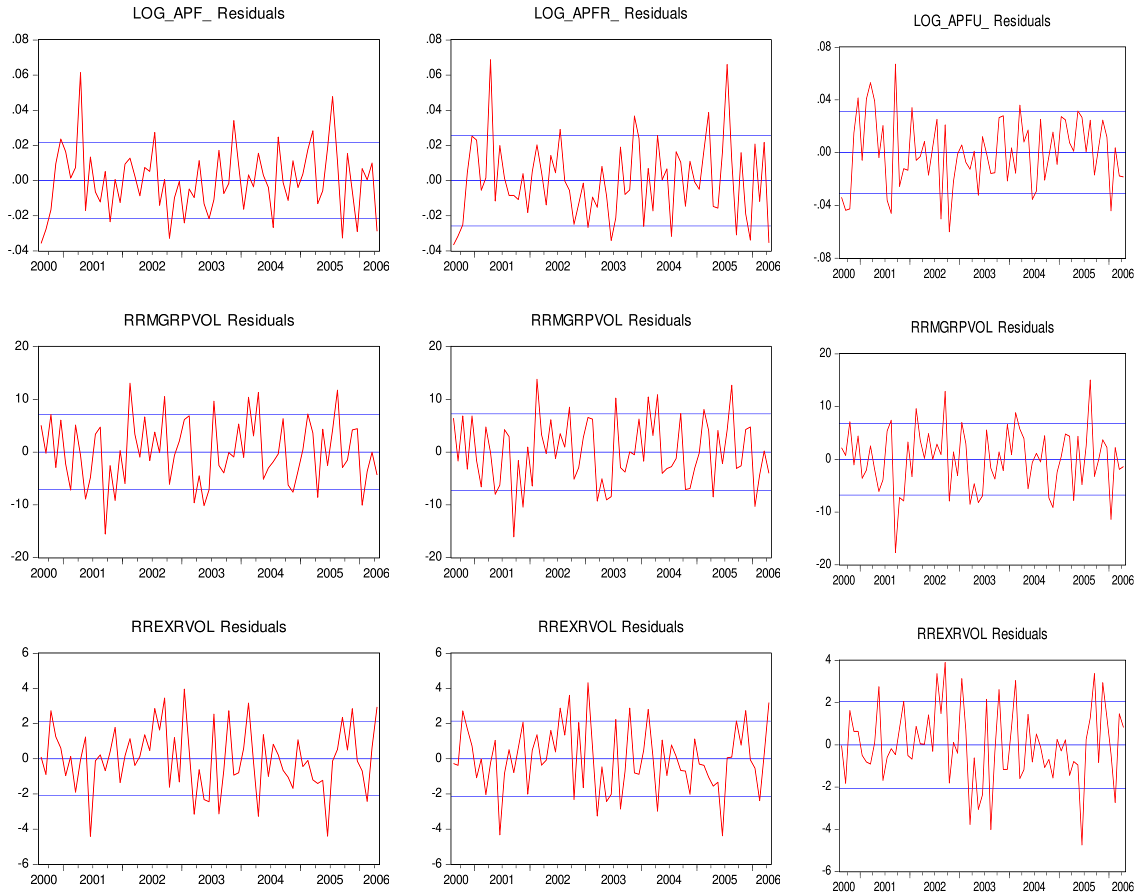
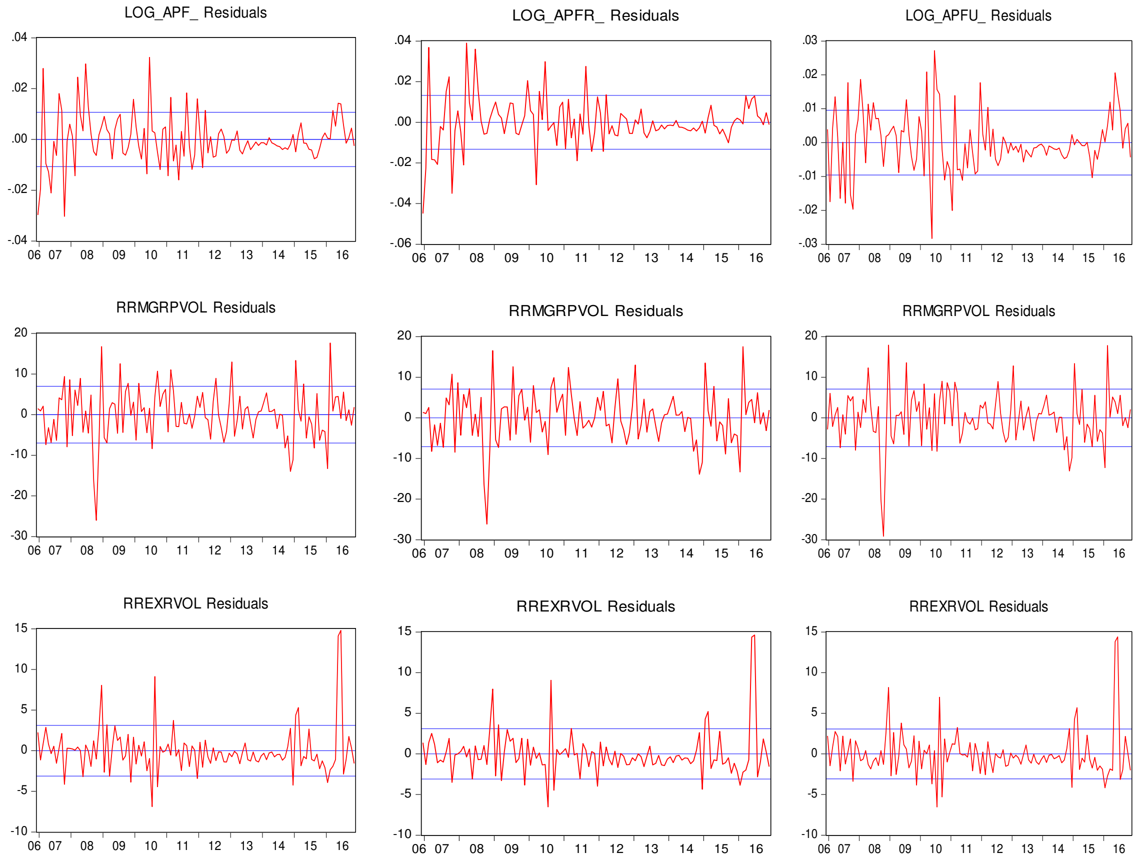


Fig. 5.3 Time Series of Residuals of Estimated Todayamamoto model for Post-crisis Periods



5.6 Granger Causality Tests

From equation 11 a granger causality test is conducted to determine the direction of causality among the variables, according to Toda and Yamamoto [64].

5.6.1 Causality Test for APF in the Full Sample Period

Table5.8 reveals the results of causality among the dependent and independent variables. It shows that a unidirectional causality runs from aggregate average price of food (APF) to real exchange rate volatility (REXRVOL) at 1% level of significance and does not granger cause real mobile gasoline retail price returns volatility in the full sample periods. On the other hand, causality runs from real mobile gasoline retail price volatility (RMGRPVOL) to aggregate price of food (APF) in a unidirectional manner while a bidirectional causality relationship exists between RMGRPVOL and REXRVOL in the full sample periods. This supports the assertions of Udoh and Egwaikhide [20].

5.6.2 Causality Test for APF in the Pre-Crisis Period

During this period, table 5.6 shows that APF granger causes REXRVOL in a one-way direction and does not granger cause RMGRPVOL. On the other hand, a unidirectional causality runs from RMGRPVOL to APF and REXRVOL in the pre-crisis periods.

5.6.3 Causality Test for APF in the Post-Crisis Period

During this period, table 5.8 shows that RMGRPVOL granger causes APF at 5% level of significance in a one-way direction. On the other hand, a unidirectional causality runs from REXRVOL to RMGRPVOL and to APF in the post-crisis periods. This toes the line of argument by Siami-Namini and Hudson [56].

5.6.4 Causality Test for APFR in the Full Sample Period

The granger causality results in table 5.8 show that a unidirectional causality runs from APFR to REXRVOL in the full sample period while bidirectional causality runs from RMGRPVOL to REXRVOL. On the other hand, RMGRPVOL granger causes APFR in a unidirectional manner from RMGRPVOL to APFR at 5% level of significance.

5.6.5 Causality Test for APFR in the Pre-Crisis Period

Table 5.8 below shows that there is a unidirectional causality from both RMGRPVOL and APFR to REXRVOL. It also reveals no causality from RMGRPVOL and REXRVOL to APFR.

5.6.6 Causality Test for APFR in the Post-Crisis Period

A unidirectional causality runs from RMGRPVOL to APFR at 5% level of significance while REXRVOL granger causes RMGRPVOL in a unidirectional way. The result in table 5.8 shows that no granger causality between APFR and REXRVOL in the post crisis periods. In the post-crisis periods prices are highly volatile, hence, spills over into the rural economic activities.

5.6.7 Causality Test for APFU in the Full Sample Period

During the full sample periods APFU granger causes REXRVOL in a unidirectional manner at 5% while RMGRPVOL granger causes APFU at 5% and REXRVOL at 5% in a unidirectional way and a bidirectional way respectively. This is evident in the rate at which both oil and exchange rates are pressurised in the urban centres. Hence, their volatility disturbs activities in the food market.

5.6.8 Causality Test for APFU in the Pre-Crisis Periods

The results in the pre-crisis periods show that unidirectional causality runs from APFU to REXRVOL at 5% level of significance while RMGRPVOL causes APFU at 5% and REXRVOL at 5% level of significance in a unidirectional manner respectively.

5.6.9 Causality Test for APFU in the Post-Crisis Period

Table 5.8 reports bidirectional causality between RMGRPVOL and REXRVOL in the post crisis periods. It further reveals that no causality exists between the two variables and APFU in the post-crisis. This disagrees with the argument of Siami-Namini and Hudson [56] and Wang et al. [53].

Table 5.8 Result of Granger Causality

APF									
	Full Sample			Pre-Crisis			Post-Crisis		
	Log(apf)	rmgrpvol	rexrvol	Log(apf)	rmgrpvol	rexrvol	Log(apf)	rmgrpvol	rexrvol
Log(apf)	DV	0.5092	25.0345***	DV	0.1031	48.9966***	DV	0.0322	2.7139
rrmgrpvol	10.3269**	DV	8.6595**	6.2404**	DV	6.6435**	7.3769**	DV	4.5346
rrexrvol	0.3289	7.6500**	DV	0.1099	3.0595	DV	0.6942	7.5347**	DV
APFR									
	Log(apfr)	rmgrpvol	rexrvol	Log(apfr)	rmgrpvol	rexrvol	Log(apfr)	rmgrpvol	rexrvol
Log(apfr)	DV	1.2461	22.2339***	DV	0.4706	45.9974***	DV	0.0376	2.4194
rmgrpvol	9.5514**	DV	8.1621**	4.0992	DV	6.0438**	7.3248**	DV	4.3422
rexrvol	0.2904	7.3305**	DV	0.3404	3.0478	DV	1.2498	7.3551**	DV
APFU									
	Log(apfu)	rmgrpvol	rexrvol	Log(apfu)	rmgrpvol	rexrvol	Log(apfu)	rmgrpvol	rexrvol
Log(apfu)	DV	2.3086	7.4332**	DV	1.6865	11.0652**	DV	1.9411**	0.5673
rmgrpvol	8.4603**	DV	10.2809**	12.4051**	DV	9.0536**	1.4077	DV	4.7235*
rexrvol	0.7402	8.1720**	DV	0.8655	3.7611	DV	1.2662	8.8489**	DV

*Note: *,**,*** denotes 10%,5%,1% and D.V= Dependent Variable. Read table in columns. For example, statistic 10.3269 tests for the null of non-Granger causality from oil price to average prices of food.*

5.7 Impulse Response Function

Alege [78] argued that impulse response has the ability to trace out endogenous variables in a situation where a model responds to the shocks undermining economic activities. Since our major concern is to determine the direction of variation in the average price of food (APF) as a result of oil price shocks, we will analyse only the first set of graphs under each equations for the various periods.

5.7.1 Impulse Response Function for APF in Full Sample Period

Under the full sample, the impulse response function shows that aggregate price of food (APF) greatly responds positively to shocks from it; surprisingly responds negatively to oil price shocks in the first three years and positively to oil price shocks beyond this period. However, it turns out be insignificant as it tends towards zero after the sixth year; and negatively to real exchange rate returns shocks.

5.7.2 Impulse Response Function for APFR in Full Sample Period

Evaluating the full sample, we also discover that rural average price of food responds positively to shocks from itself; negatively to oil price shocks in the first three years and later become positive after this period to shocks from oil price volatility (RMGRPVOL) which also appears insignificant as it tends towards zero; and negatively to real exchange rate shocks (REXRVOL).

5.7.3 Impulse Response Function for APFU in Full Sample Period

The full sample reveals that urban average price of food (APFU) responds positively to shocks within itself; slightly positive to oil price shocks (RMGRPVOL) from the beginning of the first year and significant; and negatively to real exchange rate shocks (REXRVOL).

5.7.4 Impulse Response Function for APF in Pre-Crisis Period

In the pre-crisis period shocks from aggregate price of food affect it (APF) positively; it slightly responds negatively to oil price shocks as well as shocks from real exchange rate returns. Shocks from real oil price volatility and real exchange volatility remain significant.

5.7.5 Impulse Response Function for APFR in Pre-Crisis Period

The graph of the impulse response function shows that rural average price of food (APFR) in pre-crisis period responds positively to shocks in it and negatively to both oil price shocks (RMGRPVOL) and real exchange rate volatility (REXRVOL) shocks.

5.7.6Impulse Response Function for APFU in Pre-Crisis Period

The impulse response for urban average price of food in post-crisis period shows that it responds positively to shocks in itself; slightly positive to oil price shocks (RMGRPVOL) but later wears out as it tends towards zero; and negatively to real exchange rate shocks.

5.7.7Impulse Response Function for APF in Post-Crisis Period

Aggregate food price (APF) in the post-crisis period responds positively to its own shocks; slightly positive to oil price shocks, but later wears out as it tends towards zero; and negatively to real exchange rate shocks.

5.7.8Impulse Response Function for APFR in Post-Crisis Period

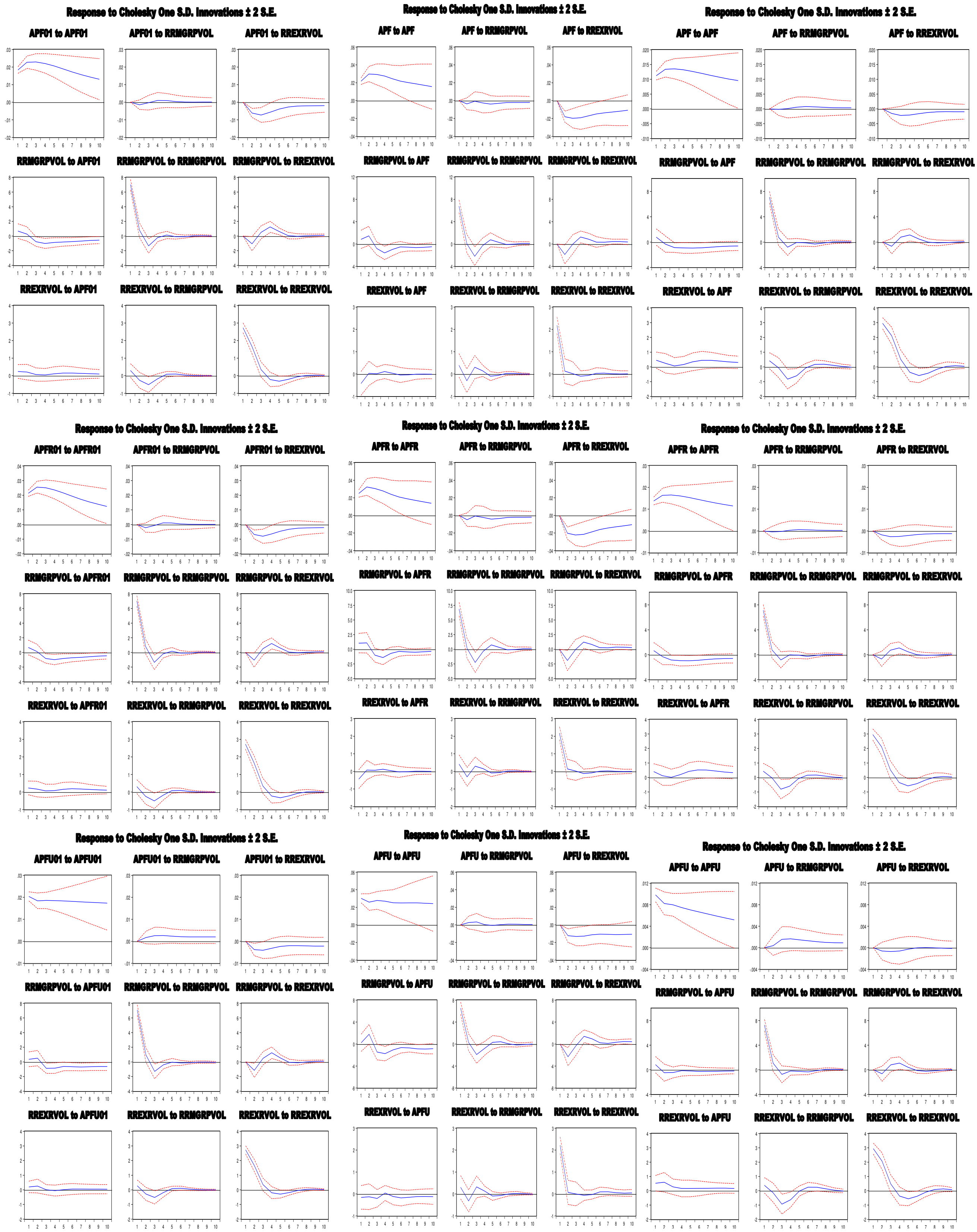
Impulse response in fig. 5.3 below shows that rural average price of food (APFR) in pre-crisis period responds positively to its own shocks; slightly positive to oil price shocks (RMGRPVOL), but tends towards zero as it wears out; and negatively to real exchange rate shocks (REXRVOL).

5.7.9 Impulse Response Function for APFU in Post-Crisis Period

Fig. 10 reports that urban average price of food (APFU) responds positively to its own shock; largely positively to oil price shocks (RMGRPVOL) which is significant and real exchange rate shocks (REXRVOL) in post-crisis period.

Fig. 5.4 Impulse Response Function

Full Sample **Pre-Crisis** **Post-Crisis**



5.8 Variance Decomposition

The evaluation of the variance decomposition allows us to make inference over the percentage of changes that is attributable to a market own shocks against shocks to other variables in the system. The estimation of equation 16 gives the results in table 5.9. Table 5.9 presents the results for the variance decomposition within a period horizon of *10, 20* and *30*-year for the full sample, pre-crisis and post-crisis periods.

5.8.1 Variance Decomposition of APF in Full Sample Period

The variance decomposition in the full sample period for the different time horizons shows that in the first 10-year *95.55* percent of innovations in aggregate price of food (APF) are explained by its own part values while only *0.12* percent and*4.34* percent of innovations are attributable to shocks to oil price volatility (RMGRPVOL) and real exchange rate volatility (REXRVOL).

Extension of the time horizon to *30* reveals that *95.98* percent of innovations in aggregate price of food (APF) are explained by its own part values while only *0.10* percent and *3.93* percent of innovations are attributable to shocks to oil price volatility (RMGRPVOL) and real exchange rate volatility (REXRVOL).This implies that the effect of oil price volatility spillover on aggregate price of food is higher in the short run relative to the long run during this period.

5.8.2 Variance Decomposition of APFR in Full Sample Period

Table 5.9 reports that given a *10*-year time horizon, *94.98* percent of innovations in rural price of food (APFR) are explained by its own part values while only *0.18* percent and *4.84* percent of innovations are attributable to shocks to oil price volatility (RMGRPVOL) and real exchange rate volatility (REXRVOL).

Extension of the time horizon to *30*reveals that *95.27* percent of innovations in rural average price of food (APFR) are explained by its own part values while only *0.16* percent and *4.57* percent of innovations are attributable to shocks to oil price volatility (RMGRPVOL) and real exchange rate volatility (REXRVOL). Sequel to the results above, we can conclude that rural average price of food is greatly affected by oil price shocks in short run than it does in the long run.

5.8.3 Variance Decomposition of APFU in Full Sample Period

Table 5.7 reports that evaluating the full sample, *96.81* percent of innovations in urban price of food (APFU) are explained by its own part values while only *1.20* percent and *1.99* percent of innovations are attributable to shocks to oil price volatility (RMGRPVOL) and real exchange rate volatility (REXRVOL) in a *10*-year horizon.

A *30*-year horizon reveals that *97.05* percent of innovations in urban average price of food (APFU) are explained by its own part values while only *1.24* percent and *1.71*percent of innovations are attributable to shocks to oil price volatility (RMGRPVOL) and real exchange rate volatility (REXRVOL). Summarily, this response of the food prices is contrary to the apriori expectations that in the long run the degree of innovations on a variable as result of its own shock declines while the variation attributable to other shocks increases (Salisu, [72]).

5.8.4 Variance Decomposition of APF in Pre-Crisis Period

The decomposition of variance in periods prior to the crisis era shows that given a *10*-year horizon, *70.26* percent of innovations in aggregate price of food (APF) are explained by its own part values while only *0.82* percent and *28.92* percent of innovations are attributable to shocks to oil price volatility(RMGRPVOL) and real exchange rate volatility(REXRVOL).

A *30*-year horizon reveals that *69.71* percent of innovations in aggregate price of food (APF) are explained by its own part values while only *0.86* percent and *29.44* percent of innovations are attributable to shocks to oil price volatility (RMGRPVOL) and real exchange rate volatility (REXRVOL).

5.8.5 Variance Decomposition of APFR in Pre-Crisis Period

The decomposition of variance in periods prior to the crisis era shows that given a *10*-year horizon, *67.21* percent of innovations in rural average price of food (APFR) are explained by its own part values while only *0.93* percent and *31.87* percent of innovations are attributable to shocks to oil price volatility(RMGRPVOL) and real exchange rate volatility(REXRVOL).

A *30*-year horizon reveals that *66.61* percent of innovations in rural average price of food (APFR) are explained by its own part values while only *0.95* percent and *32.44* percent of innovations are attributable to shocks to oil price returns (RMGRPVOL) and real exchange rate volatility (REXRVOL).

5.8.6 Variance Decomposition of APFU in Pre-Crisis Period

The decomposition of variance in periods prior to the crisis era shows that given a *10*-year horizon, *84.85* percent of innovations in urban average price of food (APFU) are explained by its own part values while only *0.25* percent and 14.90 percent of innovations are attributable to shocks to oil price volatility (RMGRPVOL) and real exchange rate volatility (REXRVOL).

A *30*-year horizon reveals that *84.29* percent of innovations in urban average price of food (APFU) are explained by its own part values while only *0.13* percent and *15.58* percent of innovations are attributable to shocks to oil price volatility (RMGRPVOL) and real exchange rate volatility (REXRVOL). The behaviour of the prices of food in the pre-crisis periods conjures with the apriori expectations that in the long run the degree of innovations on a variable as result of its own shock declines while the percentage of variation attributable to other shocks increases (Salisu, [72]).

5.8.7 Variance Decomposition of APF in Post-Crisis Period

The decomposition of variance in periods in and after the crisis era shows that given a *10*-year horizon, *98.48* percent of innovations in aggregate price of food (APF) are explained by its own part values while only *0.15* percent and *1.38* percent of innovations are attributable to shocks to oil price volatility(RMGRPVOL) and real exchange rate volatility(REXRVOL).

A *30*-year horizon reveals that *98.58* percent of innovations in aggregate price of food (APF) are explained by its own part values while only *0.15* percent and *1.27* percent of innovations are attributable to shocks to oil price volatility (RMGRPVOL) and real exchange rate volatility (REXRVOL).

5.8.8 Variance Decomposition of APFR in Post-Crisis Period

The decomposition of variance in periods in and after the crisis era shows that given a *10*-year horizon, *98.50* percent of innovations in rural average price of food (APFR) are explained by its own part values while only 0.06 percent and 1.44 percent of innovations are attributable to shocks to oil price volatility (RMGRPVOL) and real exchange rate volatility (REXRVOL).

A *30*-year horizon reveals that *98.57* percent of innovations in rural average price of food (APFR) are explained by its own part values while only *0.06* percent and *1.37* percent of innovations are attributable to shocks to oil price volatility (RMGRPVOL) and real exchange rate volatility (REXRVOL).

5.8.9 Variance Decomposition of APFU in Post-Crisis Period

The decomposition of variance in periods in and after the crisis era shows that given a 10-year horizon, 97.24 percent of innovations in urban average price of food (APFU) are explained by its own part values while only 2.49 percent and 0.26 percent of innovations are attributable to shocks to oil price volatility (RMGRPVOL) and real exchange rate volatility (REXRVOL).

A *30*-year horizon reveals that *97.14* percent of innovations in rural average price of food (APFR) are explained by its own part values while only *2.66* percent and *0.20*percent of innovations are attributable to shocks to oil price volatility (RMGRPVOL) and real exchange rate volatility (REXRVOL).

Table 5.9 Percentage contributions to Average Prices of Food variations at the horizon of 10, 20 and 30 periods

Full sample				**Pre-crisis**				**Post-crisis**			
Period	Apf	rrmgrpvol	rrexrvol	Period	Apf	rrmgrpvol	rrexrvol	Period	Apf	Rrmgrpvol	rrexrvol
APF											
10	95.55	0.12	4.34	10	70.26	0.82	28.92	10	98.48	0.15	1.38
20	95.93	0.10	3.98	20	69.78	0.85	29.37	20	98.56	0.15	1.29
30	95.98	0.10	3.93	30	69.71	0.86	29.44	30	98.58	0.15	1.27
APFR											
10	94.98	0.18	4.84	10	67.21	0.93	31.87	10	98.50	0.06	1.44
20	95.24	0.16	4.60	20	66.66	0.95	32.39	20	98.56	0.06	1.39
30	95.27	0.16	4.57	30	66.61	0.95	32.44	30	98.57	0.06	1.37
APFU											
10	96.81	1.20	1.99	10	84.85	0.25	14.90	10	97.24	2.49	0.26
20	96.99	1.23	1.78	20	84.43	0.16	15.40	20	97.15	2.63	0.21
30	97.05	1.24	1.71	30	84.29	0.13	15.58	30	97.14	2.66	0.20

Source: Computed by the author
Note: all terms remain as defined in chapter 4. 10, 20 and 30 are the time lag interval which defines the short run and long run periods.

SUMMARY, CONCLUSIONS AND RECOMMENDATION

6.1 Summary

This study has performed a comprehensive analysis of the relationship between oil price shocks (RMGRPVOL) and prices of food (aggregate price of food (APF), rural average price of food (APFR) and urban average price of food (APFU)) in Nigeria with GARCH (1,1)-TY model. Findings show that oil price shocks are highly persistent and slowly revert to mean in both full sample period and post-crisis period without structural breaks but weak in the pre-crisis periods and reverts faster to the mean. The study further reveals that oil price shocks granger cause prices of food in the full sample periods. However, the causality also runs from oil price shocks to prices of food in the pre-crisis and post-crisis periods except for rural average price of food (APFR) in the pre-crisis period. This is because the persistence of shock is weak, temporary and reverts faster to mean.

The results of our impulse response largely support the argument that prices of food are positively related to oil price shocks. However, this differs as a result of the break. For example, oil price shocks though insignificant positively affect the prices of food in the full sample and post crisis periods except for urban price of food in the post-crisis period which is positive and also significant. The reverse is the case in the pre-crisis period having acknowledged the fact that there is no volatility, hence, the effect of oil price shocks in the pre-crisis periods are insignificant.

The study also asserts that shocks to prices of food in all the periods are greatly attributed to itself. Although, shocks in rural price of food both in full sample and post-crisis periods are accounted for by insignificant oil price shocks but higher in the pre-crisis periods which we discover is not in existence. The reverse is the case in the urban areas has shocks to urban price of food are attributable to oil price shocks are higher than that of rural price of food in the post crisis period but lesser in the pre-crisis periods.

6.2 Conclusions

Exploring the various sectors of the Nigerian economy, scholars have studied the relationship between oil price shocks and disaggregated prices of food but the rural-urban prices of food-oil price shocks nexus is an area yet to be properly explored.

The major objective of this paper was to examine crude oil price volatility spillover effects on average price of food, hence, we adopt the GARCH(1, 1)-TY model with impulse response to measure volatility and effects. One interesting innovation of the study was that it evaluated the oil price volatility spillover effects on the rural average price of food and urban average price of food at varying periods. We discover that oil price shocks are persistence and permanent in full sample and post-crisis periods while it fades off in the pre-crisis periods.

Generally, the study aligns with the strands of literature that argued that oil price shocks positively affect prices of food, but a disaggregation of food prices into rural and urban prices at different periods further validates this assertion. Our impulse response results show that aggregate price of food (APF), rural average price of food (APFR) and urban average price of food (APFU) positively respond to oil price shocks in all through the periods except rural average price of food (APFR) which responds negatively to oil price shocks in the pre-crisis periods. However, the response of the urban average price of food proves to be more significant in the post-crisis periods as it appears relatively most affected in the post-crisis by a greater percentage of oil price shocks.

It therefore, affirmed that oil price shocks positively affect urban average prices of food more significantly in the post-crisis and full sample period than rural average price of food in the same periods. This is attributable to the ability of the rural dwellers to resolve to the use of fossil fuel during these periods which are certainly not available in most urban areas. On the other hand, Oil price shocks greatly affects rural average price of food negatively in the pre-crisis period, although insignificant, this is shown by the GARCH (1,1) effects, impulse response and impulse decomposition results.

6.3 Recommendation

Topics such as rural-urban migration and rural-urban cost of living are vocal topics in economics which have aided government as well as business owners in policy formulation. The study of oil price shocks effects spillover on rural and urban average price of food is important as it will help the government to further set her priorities in terms of agricultural policies, oil related policies and pricing policies at different periods in the life cycle of the economy. Different strokes they say for different folks, hence, different policy frames will be required to cushion the effects of oil price shocks on the prices of food in the rural and urban areas as the effects of these shocks are more pronounced in urban areas than in rural areas.

6.4 Limitations of the Study and Further Studies

This research is not exempted from the bottlenecks of data dearth in Nigeria. This is why the data covers period from January 2000 to December 2016. Hence, we use readily available data from international agencies as well as Central Bank of Nigeria during these periods. The symmetry and asymmetry effects of oil price volatility on rural and urban average prices of food can further be researched by scholars to validate or discard the findings of this study using more sophisticated econometric tool like Support Vector Regression (SVR)-GARCH model.

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APPENDIX 1

Granger Causality among APF, RMGRPVOL and REXRVOL in Full Sample Period

TODAYAMAMOTO Granger Causality/Block Exogeneity Wald Tests
Date: 09/24/18 Time: 20:28
Sample: 2000M01 2016M12
Included observations: 197

Dependent variable: APF01

Excluded	Chi-sq	df	Prob.
RMGRPVOL	0.509163	2	0.7752
REXRVOL	25.03452	2	0.0000
All	27.35827	4	0.0000

Dependent variable: RMGRPVOL

Excluded	Chi-sq	df	Prob.
APF01	10.32694	2	0.0057
REXRVOL	8.659465	2	0.0132
All	21.10094	4	0.0003

Dependent variable: REXRVOL

Excluded	Chi-sq	df	Prob.
APF01	0.328912	2	0.8484
RMGRPVOL	7.650010	2	0.0218
All	8.044950	4	0.0899

Source: Eviews 9

APPENDIX 2

Granger Causality among APFR, RMGRPVOL, and REXRVOL in Full Sample Period

TODAYAMAMOTO Granger Causality/Block Exogeneity Wald Tests
Date: 09/24/18 Time: 20:30
Sample: 2000M01 2016M12
Included observations: 197

Dependent variable: APFR01

Excluded	Chi-sq	df	Prob.
RMGRPVOL	1.246111	2	0.5363
REXRVOL	22.23389	2	0.0000
All	25.80256	4	0.0000

Dependent variable: RMGRPVOL

Excluded	Chi-sq	df	Prob.
APFR01	9.551423	2	0.0084
REXRVOL	8.162131	2	0.0169
All	20.28637	4	0.0004

Dependent variable: REXRVOL

Excluded	Chi-sq	df	Prob.
APFR01	0.290361	2	0.8649
RMGRPVOL	7.330496	2	0.0256
All	8.004790	4	0.0914

Source: Eviews 9

APPENDIX 3

Granger Causality among APFU, RMGRPVOL, and REXRVOL in Full Sample Period

TODAYAMAMOTO Granger Causality/Block Exogeneity Wald Tests
Date: 09/24/18 Time: 20:34
Sample: 2000M01 2016M12
Included observations: 197

Dependent variable: APFU01

Excluded	Chi-sq	df	Prob.
RMGRPVOL	2.308591893576711	2	0.3152794322780327
REXRVOL	7.433233215993183	2	0.02431609972252946
All	9.494738791274769	4	0.04985546588613154

Dependent variable: RMGRPVOL

Excluded	Chi-sq	df	Prob.
APFU01	8.460322719983054	2	0.01455004256424097
REXRVOL	10.28089034039795	2	0.005855082624782515
All	19.12059964089066	4	0.0007442019286482138

Dependent variable: REXRVOL

Excluded	Chi-sq	df	Prob.
APFU01	0.7401853707190941	2	0.6906703126443793
RMGRPVOL	8.171947047560531	2	0.0168067695592472
All	8.481234843635004	4	0.0754580729732548

Source: Eviews 9

APPENDIX 4

Granger Causality among APF, RMGRPVOL, and REXRVOL in Pre-Crisis Period

TODAYAMAMOTO Granger Causality/Block Exogeneity Wald Tests
Date: 09/24/18 Time: 20:46
Sample: 2000M01 2006M04
Included observations: 70

Dependent variable: APF

Excluded	Chi-sq	df	Prob.
RMGRPVOL	0.103089	2	0.9498
REXRVOL	48.99664	2	0.0000
All	51.08774	4	0.0000

Dependent variable: RMGRPVOL

Excluded	Chi-sq	df	Prob.
APF	6.240366	2	0.0441
REXRVOL	6.643471	2	0.0361
All	13.15507	4	0.0105

Dependent variable: REXRVOL

Excluded	Chi-sq	df	Prob.
APF	0.109881	2	0.9465
RMGRPVOL	3.059461	2	0.2166
All	3.246853	4	0.5174

Source: Eviews 9

APPENDIX 5

Granger Causality among APFR, RMGRPVOL, and REXRVOL in Pre-Crisis Period

TODAYAMAMOTO Granger Causality/Block Exogeneity Wald Tests
Date: 09/24/18 Time: 20:48
Sample: 2000M01 2006M04
Included observations: 70

Dependent variable: APFR

Excluded	Chi-sq	df	Prob.
RMGRPVOL	0.470603	2	0.7903
REXRVOL	45.99735	2	0.0000
All	49.19851	4	0.0000

Dependent variable: RMGRPVOL

Excluded	Chi-sq	df	Prob.
APFR	4.099163	2	0.1288
REXRVOL	6.043793	2	0.0487
All	10.80266	4	0.0289

Dependent variable: REXRVOL

Excluded	Chi-sq	df	Prob.
APFR	0.340367	2	0.8435
RMGRPVOL	3.047794	2	0.2179
All	3.490936	4	0.4793

Source: Eviews 9

APPENDIX 6

Granger Causality among APFU, RMGRPVOL, and REXRVOL in Pre-Crisis Period

TODAYAMAMOTO Granger Causality/Block Exogeneity Wald Tests
Date: 09/24/18 Time: 20:51
Sample: 2000M01 2006M04
Included observations: 70

Dependent variable: APFU

Excluded	Chi-sq	df	Prob.
RMGRPVOL	1.686525	2	0.4303
REXRVOL	11.06520	2	0.0040
All	12.48350	4	0.0141

Dependent variable: RMGRPVOL

Excluded	Chi-sq	df	Prob.
APFU	12.40514	2	0.0020
REXRVOL	9.053599	2	0.0108
All	19.94050	4	0.0005

Dependent variable: REXRVOL

Excluded	Chi-sq	df	Prob.
APFU	0.865246	2	0.6488
RMGRPVOL	3.761142	2	0.1525
All	4.040004	4	0.4006

Source: Eviews 9

APPENDIX 7

Granger Causality among APF, RMGRPVOL, and REXRVOL in Post-Crisis Period

TODAYAMAMOTO Granger Causality/Block Exogeneity Wald Tests
Date: 09/24/18 Time: 20:55
Sample: 2006M05 2016M12
Included observations: 121

Dependent variable: APF

Excluded	Chi-sq	df	Prob.
RMGRPVOL	0.032180	2	0.9840
REXRVOL	2.713900	2	0.2574
All	2.882151	4	0.5777

Dependent variable: RMGRPVOL

Excluded	Chi-sq	df	Prob.
APF	7.376864	2	0.0250
REXRVOL	4.534557	2	0.1036
All	12.45233	4	0.0143

Dependent variable: REXRVOL

Excluded	Chi-sq	df	Prob.
APF	0.694192	2	0.7067
RMGRPVOL	7.534668	2	0.0231
All	8.920715	4	0.0631

Source: Eviews 9

APPENDIX 8

Granger Causality among APFR, RMGRPVOL, and REXRVOL in Post-Crisis Period

TODAYAMAMOTO Granger Causality/Block Exogeneity Wald Tests
Date: 09/24/18 Time: 20:59
Sample: 2006M05 2016M12
Included observations: 121

Dependent variable: APFR

Excluded	Chi-sq	df	Prob.
RMGRPVOL	0.037573	2	0.9814
REXRVOL	2.419437	2	0.2983
All	2.610158	4	0.6250

Dependent variable: RMGRPVOL

Excluded	Chi-sq	df	Prob.
APFR	7.324789	2	0.0257
REXRVOL	4.342206	2	0.1141
All	12.36587	4	0.0148

Dependent variable: REXRVOL

Excluded	Chi-sq	df	Prob.
APFR	1.249833	2	0.5353
RMGRPVOL	7.355096	2	0.0253
All	9.581721	4	0.0481

Source: Eviews 9

APPENDIX 9

Granger Causality among APFU, RMGRPVOL, and REXRVOL in Post-Crisis Period

TODAYAMAMOT0 Granger Causality/Block Exogeneity Wald Tests
Date: 09/24/18 Time: 21:01
Sample: 2006M05 2016M12
Included observations: 121

Dependent variable: APFU

Excluded	Chi-sq	df	Prob.
RMGRPVOL	1.941101	2	0.3789
REXRVOL	0.567297	2	0.7530
All	2.757378	4	0.5992

Dependent variable: RMGRPVOL

Excluded	Chi-sq	df	Prob.
APFU	1.407661	2	0.4947
REXRVOL	4.723476	2	0.0943
All	6.311091	4	0.1771

Dependent variable: REXRVOL

Excluded	Chi-sq	df	Prob.
APFU	1.266173	2	0.5310
RMGRPVOL	8.848925	2	0.0120
All	9.420660	4	0.0514

Source: Eviews 9