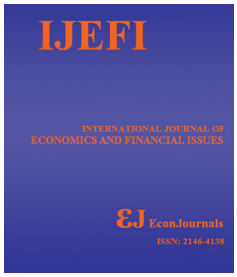

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Volatility and Commodity Price Dynamics in Nigeria

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ABSTRACT

This study examines volatility and commodity price dynamics in Nigeria. This was estimated with the generalized autoregressive conditional heteroschedasticity (GARCH) and exponential GARCH, while granger causality test was used to examine the causality direction between domestic commodity prices and spot price of commodity derivatives. The result shows that 30% of volatility in the spot international commodity market can be explained by volatility in domestic and international export commodity prices, while international oil spot prices explains 7% volatility in prices of goods consumed locally and export commodity price index explains 16% of spot price of international commodity between 2000 and 2013 in Nigeria. Inflation and exchange rate is shown to be significantly related to spot price volatility which accounts for its volatility also. Hence, as such, the clamor for a more stable and robust revenue generating sector cannot be over emphasized - the so much talked about diversification.

Keywords: Volatility, Dynamics, Spot Price, Causality, Inflation, Exchange Rate
JEL Classifications: E3, E32, C32, O24, F31

1. INTRODUCTION

Understanding volatility and its behavior has been of key interest to economies in the past decades that have shown highly volatile changes in prices both in the equity and commodity market. Volatility measures the fluctuation in the value of a variable, especially price. Based on the seminal work of Samuelson (1965), it is now widely accepted that commodity prices fluctuate randomly. Understanding the stochastic behavior of commodity prices is essential for many agents where some countries base their economic development on the production and export of commodities. Such countries are highly exposed to commodity price fluctuations due to volatile commodity prices in the international market which has implication for valuation and hedging.

Hence, the issue of commodity dynamics in Nigeria has been a history of commodity struggle where crude oil usually takes predominance over the commodity complex such as metal, oil; precious metal and agro products among others. According to Olotu et al. (2013), the pattern of economic volatility is complex in Nigeria. At the macroeconomic level the high volatility recorded in real growth rates, inflation, government revenues, terms of trade and real exchange rate closely reflect the movements of oil prices. Abebefe (1995) noted that the vagaries of the oil market has resulted in a significant decline in the earnings because of the exogenously determined price of crude oil which has led to shocks in earnings of stakeholders in the international commodity market and the nation's coffer. This has made researchers to employ spot prices of international oil commodities as a proxy for spot prices of international commodities traded in the international commodity market (Kazue, 2012) and there is gainsay that the international oil market is a reflection of not just the demand and supply of crude oil but of the global market place. Additionally, besides oil price volatility as a major cause of macroeconomic disturbance, external shocks may also arise from other non-fuel commodity price fluctuation. This effect according to Iyoha (2004) could however vary, depending on the effect of this price on the demand and supply sides of the economy. The government in a bid create a veritable platform to mitigate the inherent risks in commodity production and marketing established Abuja securities and commodity exchange which has not taken off the ground since it was established in August, 2001.

According to Chris and Marcel (2011), interest in commodity derivatives in the futures market has grown enormously over the last decade for a variety of reasons which includes relatively poor performances of stocks and Treasuries. As such, investors have sought previous and unexplored asset classes as potential new sources of returns. Hence, International Bank for Settlement reported that the amounts of outstanding over-the-counter (OTC) commodity derivatives (forward and options) exceeded 3 trillion dollars as of June 2011, which may be as a result of low correlation between commodity returns with equities and their ability to provide a hedge against inflation due to high shocks in spot prices of international commodities; and the liberalization of numerous markets that led to increase in corporate requirements for hedging.

Given that commodity trading in the 2000s is fast gaining relevance in the global market, one would be left to wonder where Nigeria stand as this field raises renewed interest by participants, financial economist, and researchers since we base our development on the production and export of oil commodity. Furthermore, studies have largely shown the impact of international oil price on both the micro and macro sectors of the economy but have failed to look at commodities prices linkage with oil prices whilst considering the exogenous behaviour of oil prices. This multivariate linkage in international commodity prices (both in the domestic and international market place) is necessary for a sound modeling of prices behaviour in an economy which has implications for selection and management of macroeconomic policies. According to Pirrong (1994), modeling of commodity prices have not kept pace with its relevance as a means to hedge against risk due to lack of univariate analysis of commodity price dynamics, hence, as volatility in commodity prices in Nigeria continue to reflect shocks in the international commodity market, we consider the mirror side view of spot prices of Nigerian commodities as a reflection of exported international commodity grades as members of same commodity type (SITCs).

Today, the economy experiences a typical Dutch-disease type structural shift and now heavily depends on oil commodity exports. This reliance has made commodity spot markets to serve as a bail-out for funds both to private entities and government. Hence, the relationship between domestic cum international commodity price fluctuation and spot price of commodity grades exposes the volatile relationship Nigeria has with the global economy which has implication for both private and government earning given Nigeria's visible presence in the international commodity market (NYMEX) due to her oil. As noted by Olotu et al. (2010), the greatest menace to achieving a virile economy has been the persistence of fluctuations in broad macroeconomic aggregates. It is a major constraint to development, making planning more problematic and investment more risky. Thus, if concerted efforts are not made to redress the vulnerability of earnings and prices to exogenous shocks or policy volatility, Nigeria heads for a doom.

Be that as it may, Pindyck (2004) work on volatility and commodity price dynamics is a clear motivation to consider possible linkages between international commodity price dynamics and spot price which is vital in understanding the behaviour of commodity prices in an export oriented nation like Nigeria. Based on previous studies like Carppentier and Dufays (2012) and Ozge (2012), it has been found that prices of certain international commodities co-move. However, from the reviewed literature, very few works in Nigeria looks at how volatility in international oil prices affects production, and spot prices in the international commodity market. According to Chris and Marcel (2011), developing countries like Nigeria, as opposed to industrialized countries, have limited financial tools to implement financial policy. Given the relative poor performance of stocks and treasuries in the past decade with the rise in commodity trading in the 2000s, the study is prompted to understand the stochastic behavior of commodity prices whilst holding volatility in imports constant. To unravel this purpose, the study investigates the extent of household commodity price volatility; international export commodity price volatility and volatility in commodity prices on spot price of international commodity in Nigeria.

2. REVIEW OF LITERATURE

2.1. Theoretical Literature

According to Deaton and Miller (1995), even though there has been progress in the study of commodity prices, the understanding of commodity prices and the ability to forecast them remains seriously inadequate. Without such understanding, it is difficult to construct good policy rules. It is sometimes argued that if economists really understand something, they should be able to predict what will happen next. But [commodity] prices are an interesting example (stock prices are another) of an economic variable which, if our theory is correct, we should be able to predict. (Hamilton, 2009. p. 184). From the above it shows that we have a long way in understanding volatility and commodity price dynamics. Fundamental to understanding volatility in commodity market is the stochastic behavior of oil prices in the commodity market due to the fact that the spot is a product of global energy crisis in the 1970s (EIA, 2012). Hence, in a bid to understand commodity-wide volatility and its relationship with spot prices of international commodity is the development of oil pricing mechanism, here, we consider a brief overview of commodity price volatility, theories and hypothesis on commodity price volatility and the spot market which is crucial to this study. According to Ogunsakin (2013), Commodity price development in Nigeria since the late 1990's has been tremendous. It followed an upward trend with prices of metals and crude oil showing the most pronounced increase. Although booms in commodity price could be observed previously, the magnitude of the increase, its duration and its breadth are not estimated. Price developments for agricultural products have been more subdued. And even though prices for agricultural raw materials, food and beverages have been following an upward trend since late 2001, their respective gains around 30%, 50% and 70% are relatively moderate compared with non-agricultural commodity. UNCTAD (2012) explains that commodity price plays an important role in the economy of Nigeria which drives the majority of their merchandize export revenues from one single commodity or several commodities. Thus, the significance of these commodities for respective economies stems mainly from their importance as a source of foreign exchange revenue and their being responsible for the employment of large parts of the labour force, particularly in Nigeria with mainly agricultural produce.

Moreover, the current spot transactions have their origin in the first and second oil crises. Spot transactions are mainly conducted by telephone or computer network between two parties. It is an OTC market as opposed to an exchange. Spot markets do not necessarily have trading floors. The term 'spot market' applies to all spot transactions concluded in an area where strong trading activities take place. A key advantage of the OTC market is that the terms of a contract do not have to have the specifications required by an exchange. A disadvantage is that there is usually a lack of transparency in the market. Counter party risk also exists in an OTC trade, which is otherwise taken by the exchange. The main spot markets for crude oil are Rotterdam for Europe and New York for the US. These markets have their own benchmarks: Brent and WTI. In particular, Brent was the centre of spot and forward trading in the 1980s. There are other grades which have strong spot trading activities. They are: Ekofisk, Forties, Oseberg from the North Sea; Russian Urals; Dubai (UAE); Oman; Minas (Indonesia); Tapis (Malaysia); Alaska North Slope (ANS) and West Texas Sour in the US; and Forcados and Bonny light from Nigeria. Although most OPEC grades are contracted on a long-term basis, some OPEC countries are known to use spot transactions to sell part of their production. The main markets for petroleum products are located in Northwest Europe (Amsterdam, Rotterdam, Antwerp), the Mediterranean (Genoa, Lavera), the Gulf, Southeast Asia (Singapore), US Gulf of Mexico (including the Caribbean) and US East Coast (New York). Aside from petroleum products non-oil commodities are also traded on an open market floor.

2.1.1. Theories on commodity price volatility - theory of storage

The theory of storage has major implications for the role of inventory in determining commodity prices and their volatility. The storage theory has a long history, introduced in the seminal papers of Kaldor (1939), Working (1948), Brennan (1958) and Telser (1958), Gustafson (1958) and later exhaustively presented by Williams and Wright (1991), links the spot price with the contemporaneous futures price through a no-arbitrage relationship known as the "cost-of-carry model." This theory is based on the notion of "convenience yield," which is associated with the increased utility from holding inventories during periods of scarce supply. The classical no-arbitrage relationship between spot and futures prices is given by: $F_{t,T} = S_t(1 + R_{t,T}) + w_{t,T} - y_{t,T}$ (1). Where $F_{t,T}$ is the price at time *t* of a futures contract maturing at T, S_t is the spot price of the commodity at time t, $R_{t,T}$ is the interest rate for the period from t to T, $w_{t,T}$ is the marginal cost of storage per unit of inventory from t to T, and $y_{t,T}$ is the marginal convenience yield per unit of storage. Another is the scarcity rent theory which is one of the first theories to address commodity price behaviour. This theory, which dates back to Hotelling (1931), states that because resources are non-renewable, owners will charge a higher price and thus receive a "scarcity rent." From the theory emerged the so-called Hotelling rule: A decision to extract resources based on an intertemporal arbitrage will lead to price changes corresponding to interest rate changes. Finally, mention should be made of a compelling model for predicting the prices of livestock products known as the "cobweb model." This model, which was introduced by Ezekiel (1938), considers price fluctuations as endogenous, rather than exogenous (as in the storage model). The storage model asks how exogenous shocks in the supply will be transmitted into price movements. By contrast, the cobweb theory explains that price variations are the results of the behaviour of market participants. Agent's price expectations play a crucial role in the livestock industry, where the lag between producing decision and effective production can be up to 3 years. While both the cobweb and storage theories model show how agents form their expectations, they are based on two fundamentally different assumptions: While the storage model assumes that agents have rational expectations, adherents of the cobweb model assume that producers have naive expectations. Thus, according to the cobweb model, agents will base their production decision on the prevailing price, even if they know that the next period's price will likely diverge (this explains the term "naive expectations"). By doing so, agents' expectations can create variations in price: When prices are low (high), they will reduce (increase) their production, so that the next period will see opposite high (low) prices.

2.1.2. Hypothetical explanation of changes in commodity prices

In spite of the importance of the rise and fall of commodities prices in recent years, there is no consensus among academic economists, practitioners and politicians about the causes of this development. However, one can classify the different (hypothetical) explanations into two distinct groups. These are the fundamentalist hypothesis and bull-bear hypothesis. In Stephan (2009), the summary assumptions and their conceptualization are:

The "fundamentalist hypothesis" assumes that commodity prices are determined exclusively by market fundamentals, i.e., by supply and demand conditions. Due to the predominance of rational market participants, destabilizing speculation cannot distort commodities prices (and asset prices in general) in any systematic and/or persistent way. The main assumptions and propositions underlying the "fundamentalist hypothesis" can be summarized as follows: (i) Its theoretical benchmark model is an ideal, frictionless market where all participants are equipped with perfect knowledge and where no transaction costs exist, (ii) The model underlying the "fundamentalist hypothesis" relaxes the assumptions of perfect knowledge and no transaction costs, (iii) The high transaction volumes in modern financial markets stem mainly from the activities of market makers, (iv) Speculation is an indispensable component of both, the price discovery process as well as the distribution of risks. As part of the former, speculation is essentially stabilizing, i.e., it moves asset prices smoothly and quickly to their equilibria (Friedman, 1953).

The bull-bear-hypothesis holds that speculation exerts a substantial influence on commodity prices. By using trend-following trading techniques, speculators - in particular hedge funds, commodity index funds and investment banks - cause commodity prices to move in a sequence of long-term upward trends (bull markets) and downward trends (bear markets). The "bull-bear-hypothesis" perceives trading behavior and price dynamics in asset markets as follows: (i) Imperfect knowledge is a general condition of social interaction and, hence, is characteristic also for the market place. As a consequence, actors use different models and process different information sets when forming expectations and making decisions, (ii) As human beings, actors' expectations and transactions are

governed not only by rational calculations, but also by emotional and social factors (the latter two factors are particularly important in financial markets which are at times characterized by "manic" or "depressive" phases as the asset prices themselves), (iii) Not only are expectations heterogeneous but they are often formed only qualitatively, (iv) Upward (downward) price movements - usually triggered by news - are lengthened by "cascades" of buy (sell) signals stemming from trend-following technical trading systems since "technical analysis" is the most widely used technique in short-term trading in financial markets, (v) In the aggregate, this behavior of market participants cause price runs in line with the "market mood" to last longer than counter-movements. In such a way short-term runs accumulate to long-term trends, i.e., "bull markets" and "bear markets."

2.2. Related Empirical Literature

Wang (2008) analyzed the dynamics of price and quantity determination in the international market for primary commodities empirically and theoretically. A major theme in his dissertation is the application of a stochastic dynamic general equilibrium model as a means of understanding macro and micro features of primary commodity markets. His findings was that commodity prices and Consumer price index (CPI) are cointegrated and therefore the commodity price to CPI ratio is a more potent variable to forecast future commodity price inflation than the lagged commodity price inflation typically included in univariate models.

In Carpantier and Dufays (2012) they considered the implication of theory of storage on volatility of commodity prices which states that commodity price volatility should increase when inventories are low. They documented this volatility feature by estimating asymmetric volatility models for 16 commodity return series, on the period 1994-2011 and show how to account for this feature in value-at-risk forecasting. Our contribution is threefold: (i) This study is the first to investigate systematically the volatility implication of the theory of storage for a large panel of commodity types, used in the volatility model positive return shocks as a new original proxy for inventories; and finally develop an original asymmetric version of the spline generalized autoregressive conditional heteroschedasticity (GARCH) model and find that the inventory effect remains robust if we allow the unconditional variance to vary over time. Pindyck (2004) whose work is a motivation for this work asserts that changes in volatility can affect market variables by directly affecting the marginal value of storage, and by affecting a component of the total marginal cost of production which is the opportunity cost of producing the commodity now rather than waiting for more price information. He examine the role of volatility in short-run commodity market dynamics and the determinants of volatility itself and developed a structural model of inventories, spot, and futures prices that explicitly accounts for volatility, and estimate it using daily and weekly data for the petroleum complex: Crude oil, heating oil, and gasoline.

Deaton and Miller (1995) examined commodity price behavior and growth in Africa. In particular, he discussed that the difficulties of handling price fluctuations are so severe, and policy-making in African countries so dysfunctional, that price booms and price slumps are equally to be feared. His empirical evidence revealed a close positive relationship between commodity price movements and growth. He notice that certain economics policies in Africa negate commonsense. For him, how urgent and attractive export diversification is depend greatly on whether real prices can be expected to trend up or down in the future. Hamed (2013), contributes to the theories commodity prices and exhaustible resources by examining simultaneous optimal resource extraction and dynamic capacity building. He looked at how random demand process and irreversible capacity options shape the long-term price and volatility path of exhaustible resource. The model suggest a mean-reverting price path in the initial stages of extraction which is a possible resolution for the old puzzle of why the predictions of Hotelling's model, Hotelling (1931), are not observed in reality.

Chris and Marcel (2011) studied the stochastic behavior of the prices and volatilities of a sample of six of the most important commodity markets whilst comparing these properties to those of the equity market. They observed a substantial degree of heterogeneity in the behavior of the series. Their findings show that it is inappropriate to treat different kinds of commodities as a single asset class as is frequently the case in the academic literature and in the industry. They also demonstrated that commodities can be a useful diversifier of equity volatility as well as equity returns. Yakubu et al. (2012) used box - Jenkins modelling approach for the time series analysis of Weekly (Forcados, Nigeria) Spot Price FOB (Dollars per Barrel) from August 07, 2000 to September 02, 2013. After taking the first order difference the time series seems to be stationarity. Autocorrelation and partial autocorrelation plots were used to make tentative identification of the form and order of Box - Jenkins Autoregressive Integrated Moving Average (ARIMA) models. Initially several non - seasonal ARIMA models were postulated for further analysis. Hence, ARIMA model was the best fit and was used to estimate the future prices of Nigeria's oil in the commodity market.

Kazue (2012), analyzed the effects of changes in the international oil price and price volatility on the macro economy of an African oil exporter, Nigeria. Applying the five-variable structural vector auto regression model to monthly data series from January 1970 to May 2011, impulse response functions are calculated to see the influences among the crude oil price, Nigeria's exchange rate, money supply (M2), domestic price levels (CPI) and the policy interest rate (discount rate). The estimation results suggest that Nigeria's exchange rate is affected not only by the changes in the international oil price but also by its price volatility. Olotu et al. (2013), examined the extent to which aggregate output is vulnerable to volatility in international commodity prices using a variant of the sensitivity model. From the result, the exposure of the economy to exogenous shocks (oil price and terms of trade) accentuates the vulnerability of aggregate output. Of the domestic variables employed, only fiscal balance proves significant. Contrary to expectation, money supply and interest rate are not statistically different from zero.

Machiko (2011) looked at how financialisation affects volatility of commodity price dynamics and identified factors in the financial markets that influence the interplay of demand and supply and

the behavior of the commodity market taking cognizance of the period 2002 to 2010. From his work, he identified factors that led to the unpredictable price swings from 2002 to 2010 from the standpoint of financialisation. Although he identified market fundamentals such as the influence of demand and supply on commodity prices; the author saw financialisation as determining commodity price swings resulting from the shift in market sentiments influencing virtual holding commodities - the massive liquidation of long positions in commodity futures and OTC deals through deleveraging on the part of portfolio investors.

Özge (2012) paper uses an endogenously clustered dynamic factor model to gain a better understanding of commodity price co-movements and their determinants. From a large dataset of commodity prices (i.e., crude oil, coffee, timber, grains etc.) he extracted the fundamental sources behind the price dynamics and concluded that commodity price co-movements are mostly the result of sparse cluster factors that represent correlations of distinct group of commodities. Endogenous clustering of these groups does not represent the standard narrow classifications (indexes) of commodity prices as defined by statistical agencies (e.g. IFS, BLS).

3. MODEL, DATA AND METHODOLOGICAL FRAMEWORK

The theoretical framework of this study is built on ARCH-GARCH model to estimate the persistence of volatility between spot prices in the international commodity derivatives market and commodity prices. The ARCH-GARCH model is used to capture or measure volatility and also check for its transmission and persistence while ARCH (1) is used to capture volatility clustering. The ARCH-GARCH model was modeled by Engle (1982) and by Tim Bolerslev (1986) respectively. The GARCH model was introduced by Bolerslev as an extension of a work done by Engle (1982) on the ARCH model framework and has been popular since the early 1990s. In the words of (Sjö, 2011), ARCH and GARCH models are used to model volatility clustering. Volatility clustering implies that variance appears to be high in certain periods and low in other periods, if period was characterized as high volatility, the period and near periods are likely to have a high volatility as well. The model is divided into two; the mean equation and the variance equation. The mean equation is also called the Arch equation. i.e., ARCH (p) and the variance equation also called the GARCH equation. i.e., GARCH (p, q) where (p, q) can actually represent the order of the equation. In the case where the order is (1, 1), the GARCH (1, 1) specification takes the form in model 2. There are various GARCH models but here we estimate using E-GARCH. The exponential GARCH (EGARCH) model developed by Nelson (1991) can demonstrate the existence of asymmetry in volatility with respect to the direction of real growth. The EGARCH (p, q) model is given by

$$\log \sigma_t^2 = \omega + \sum_{i=1}^{q} (\alpha_1 |Z_{i-1}| + \gamma Zi\text{-}1) + \sum_{i=1}^{p} \beta_i \log \sigma_{t-1}^2 \quad (1)$$

Where $z_t = \varepsilon_t / \sigma_t$ and ε_t is an error term. Note that the left-hand side of equation (1) is the logarithm of the conditional variance. The logarithmic form of the EGARCH (p, q) model ensures the non-negativity of the conditional variance without the need to constrain the model's coefficients. The asymmetric effect of positive and negative shocks is represented by inclusion of the term z_{i-1}. If $\gamma_t > 0$ (<0) volatility tends to rise (fall) when the lagged standardized shock, is positive (negative). The persistence of shocks to the conditi $z_{t-1} = \varepsilon_{t-1} / \sigma_{t-1}$ onal variance is given by $\sum_{i=1}^{p} \beta_i$.

In order to ensure an adequate and comprehensive research, secondary data were collected from the Central Bank of Nigeria Statistical bulletin, 2013 schedule and NYMEX monthly Brent spot prices of oil commodities which is a good proxy for Nigerian spot prices of international commodity (which is an image of the Nigerian commodity spot prices since crude oil is Nigeria's major commodity trade), for the period 2000-2013. The NYMEX market was used for our study because of its benchmark grades (BRENT, WTI, Forcadoes etc.) and the fact that it is a suitable market for African commodities like coffee, crude oil, gold and copper (Thouraya and Youssef, 2011). The econometric package used for the analysis of this work is the STATA 11 and EVIEWS 7, while data were entered by the Microsoft Excel 2010.

Model 1(a):

Model 1a and b is GARCH (1,1) model whilst we also deduce AR (1) to test for volatility clustering which will be used to answer the research objective 1 and 2.

$$CPI_t = a_0 + u_t \quad (2)$$

$$\mu_t^2 = a_0 + a_1 \mu_{t-1}^2 + \alpha_2 h_{t-1} \quad (3)$$

Model 1(b):

$$ECPI_t = a_0 + u_t \quad (4)$$

$$\mu_t^2 = a_0 + a_1 \mu_{t-1}^2 + \alpha_2 h_{t-1} \quad (5)$$

Where,

CPI: Domestic CPI of goods and services consumed by households.

ECPI: Export CPI. It includes standard international trade commodities (SITC) such as crude oil, metal, agricultural products, and minerals, among others.

a_0: The intercept term denoting the average percentage change in consumer price

μ_t: Random error term μ: The estimated residual from the regression, a_1: The intercept denoting the weight of the lagged residual while a_2 measures the degree of the volatility.

h_{t-1}: Lag volatility of commodity derivatives spot price.

Model 2:

Model 2 is a GARCH (1,1) model used to answer the research objective three. The functional form of model is specified as:

$$BOP_t = (CPI_t, EXR_t, INF_t) \quad (6)$$

The mathematical form of the model can be expressed as:

$$BOP_t=\alpha_0+\alpha_1 CPI_t+\alpha_2 EXR_t+\alpha_3 ECPI_t+\alpha_4 INF_t \quad (7)$$

But equations 6 and 7 are exact or deterministic in nature. In order to allow for the inexact relationship among the variables as in the case of most economic variables, the stochastic error term "u_t" is introduced into both equations. Therefore, the econometric form of the models can be expressed as:

$$BOP_t=\alpha_0+\alpha_1 CPI_t+\alpha_2 EXR_t+\alpha_3 ECPI_t+\alpha_4 INF_t+\varepsilon_t \quad (8)$$

Where,

BOP_t: Brent oil spot prices, which is a proxy for spot prices of Nigerian forcado crude oil commodity (used to capture spot prices in commodity market since there is no all stock price index for individual countries in the international commodity derivatives market). Using estimation of GARCH (1,1), we have:

Mean equation:

$$BOP_t=\alpha_0+\alpha_1 INF+u_t \quad (9)$$

Variance equation:

$$h_t=\alpha_2+\alpha_3 h_{t-1}+\alpha_4 e^2_{t-1}+\alpha_5 CPI_t+\alpha_6 EXR_t+\alpha_7 ECPI_t \quad (10)$$

Here, CPI, (ECPI), and (EXR) are "variance regressors," h_{t-1} is the "GARCH term" and e^2_{t-1} is the "ARCH term" while h_t is the volatility of commodity derivatives spot prices. In equation (7), the behaviour of "u_t" in the mean equation will determine our use of ARCH and GARCH model.

3.1. Granger Causality Test

Developed by Granger (1969), it is a method of testing the causal relationship between two or more time series. It is based on the equation below:

$$y_t=\alpha_1+\sum_{j=1}^{k}\beta_t\gamma_{t-j}+\sum_{j=1}^{k}\gamma_j x_{t-j}+u_{1t} \quad (11)$$

$$x_t=\alpha_2+\sum_{j=1}^{k}\theta_t\gamma_{t-j}+\sum_{j=1}^{k}\gamma_j x_{t-j}+u_{2t} \quad (12)$$

u_{1t} and u_{2t} are mutually uncorrelated error terms and "t" and "j" are the lags. Granger causality assume $\gamma_j=0$ and $\theta_t=0$ for all t's and j's for null hypothesis. If the coefficient γ_j's are statistically significant when θ_t's are not, then *x* granger causes *y*. If otherwise, *y* (spot oil price volatility) granger causes *x* (commodity price volatility). But in a situation where γ_j and θ_t are significant, the causality run both direction.

4. DISCUSSION OF THE EMPIRICAL FINDINGS

Using the Augmented Dickey Fullers unit root test we can observe that all the variables starting from the dependent variables are significantly stationary at first difference (or can be said to be integrated of order one at 5% significance level) except for inflation which is stationary at level form (Table 1). Furthermore, other pre-test such as Q-test, ARCH-test and normality test has been carried out. Where Q-test and ARCH-test has probability values that are >0.05, hence we reject H_0 which states that there is no serial correlation and no arch effect respectively which is desirable for proper estimation. Meanwhile, the normality test showed a P value of 0.0025, hence we reject the H_0 (normally distributed), however, according to (Sayed, 2009; Bollerslev, 1986; Engle, 1982) estimators are efficient even if the residuals are not normally distributed. Hence, according to GARCH model estimation criteria the normal Gaussian distribution has been employed.

4.1. Cointegration Test

Null hypothesis: U has a unit root (no Cointegration)

Decision rule: Reject H_0 if ADF t-statistical is greater than t-critical.

Augmented Dickey Fuller	t-statistic	P
ADF test statistic	−7.916691	0.0000
Test critical value: @1%	−3.476472	
@5%	−2.881685	
@10%	−2.577591	

ADF: Augmented Dickey-Fuller

From the result above, With an ADF test statistic of −7.9166 and a tabulated value of −2.8816 at 5% significance level, we reject the null hypothesis and conclude that the residual is Co-integrated. That is the independent variables (international commodity prices) share a long-run relationship with the dependent (spot price of international commodity). Hence, our result is a co-integrating one.

4.2. Model 1a (ARCH and GARCH Model)

Here we test to see if there is arch effect in CPI.

From the results shown in the table above (Table 2), χ^2 P > 0.05 indicating that there is arch effect. We therefore reject H_0 which says that there is no arch effect because having an arch effect on CPI indicates domestic commodity price volatility clustering thereby indicating that prices are subject to inflationary risks.

Dependent Variable: D (CPI) Method: ML - ARCH (Marquardt) - normal distribution GARCH=C(2) + C(3)*RESID(-1) ²+C(4)*GARCH(-1)				
Variable	**Coefficient**	**SE**	**z-statistic**	**P**
C	0.59399	0.1033	5.7450	0.0000
Variance equation				
C	0.4720	0.1455	3.2434	0.0012
RESID(-1) ²	0.5702	0.5702	2.0243	0.0429
GARCH(-1)	0.3804	0.1878	2.0258	0.0428

R^2=−0.00320. CPI: Consumer price index, ARCH: Autoregressive conditional heteroschedasticity, GARCH: Generalized autoregressive conditional heteroschedasticity

4.3. Conditional Variance of CPI

Decision rule: When P < 0.05 (the variable is significant).

From the above result, the prices of household goods and services exhibit a shock (volatility) of 38% with a significant GARCH term

which is deduced from the probability value of 0.04. While from the ARCH term we see that previous year's price significantly influences today's price by 57%.

4.4. Model 1b (ARCH and GARCH Model)

From Table 3, χ^2 probability is >0.05 indicating that there is arch effect. We therefore reject H_0 which says that there is no arch effect because having an arch effect in ECPI indicates international commodity price volatility clustering thereby indicating that prices are largely influenced by stock of goods available and demands in the international commodity market.

Dependent Variable: D (EX_CPI_) Method: ML - ARCH (Marquardt) - Normal distribution GARCH=C(2) + C(3)*RESID(−1) ²+C(4)*GARCH(−1)				
Variable	**Coefficient**	**SE**	**z-statistic**	**P**
C	0.7195	0.9179	0.7838	0.4331
Variance equation				
C	0.568919	1.3589	0.4187	0.6754
RESID(-1) ²	−0.05839	0.01905	−3.06514	0.0022
GARCH(-1)	1.0899	0.03061	35.6042	0.0000

R^2=−0.00067. NB: *Note that the R^2 is negative which is consistent with GARCH analysis where it is stated that R^2 becomes meaningless when there is no variable in the mean equation. ARCH: Autoregressive conditional heteroschedasticity, GARCH: Generalized autoregressive conditional heteroschedasticity

4.5. Conditional Variance of ECPI

Decision rule: When P < 0.05 (the variable is significant).

The result of conditional variance of ECPI shows that prices of household goods and services exhibit a shock (volatility) of about 100% with a significant GARCH term which is deduced from the probability value of 0.0000. While from the ARCH term we see that previous years price significantly and negatively influences today's price by 5%.

Figure 1 shows the extent of volatility in CPI and ECPI. As indicated in the Figure 1 above, export consumer price index measured with exchange rate volatility than consumer price index proxied with consumer price volatility (CPV).

Table 1: Statistical report of unit root test

Variables	Critical values	ADF-test statistic	Order of integration	Remark
ECPI	−2.88,197	−7.8,84,151	I(1)	Stationary
BOP	−2.8,81,830	−11.33,034	I(1)	Stationary
CPI	−2.88,183	−13.24,749	I(1)	Stationary
INF	−2,88,212	−2.9978	I(0)	Stationary
LEXR	−2,88,375	−3.7923	I(1)	Stationary

ECPI: Export consumer price index, BOP: Brent oil spot prices, CPI: Consumer price index, ADF: Augmented Dickey-Fuller

Table 2: ARCH-M results for model 1a

Lags	χ^2	DF	P>χ^2
1	76.520	1	0.0000

ARCH: Autoregressive conditional heteroschedasticity

Table 3: ARCH-M results

Lags	χ^2	DF	P>χ^2
1	0.353	1	0.5527

H0: No ARCH effect, H1: ARCH effect, ARCH: Autoregressive conditional heteroschedasticity

Dependent variable: DLOG (BOP) Method: ML-ARCH (Marquardt) – Normal distribution GARCH = C(2)+C(3)*RESID(−1)² +C(4)*GARCH(−1)+C(5)*EV+C(6)*CPV				
Variable	**Coefficient**	**SE**	**z-statistical**	**P**
C	0.016470	0.00609	2.70157	0.0069
Variance equation				
C	0.011938	0.00224	5.3071	0.0000
RESID(-1)²	0.349281	0.09080	3.8463	0.0001
GARCH(-1)	−0.300890	0.08866	−3.3936	0.0007
EV	−1.67E-05	5.21E-06	−3.2012	0.0014
CPV	−7.29E-05	2.46E-05	−2.9677	0.0030

R^2=−0.004613. NB: *Note that the R^2 is negative which is consistent with GARCH analysis where it is stated that R^2 becomes meaningless when there is no variable in the mean equation. ARCH: Autoregressive conditional heteroschedasticity, GARCH: Generalized autoregressive conditional heteroschedasticitys, BOP: Brent oil spot prices

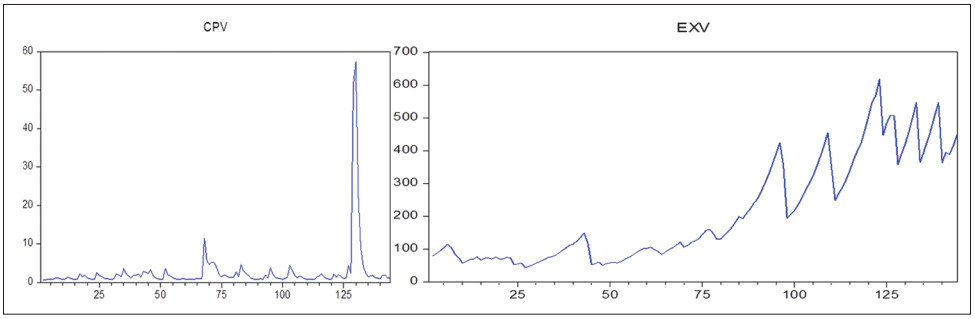
Decision rule: When P < 0.05; there is a significant relationship between that variable and spot price volatility (which is the dependent variable).

From the above table, spot price volatility is not significantly explained by ECPI of SITCs. Here, spot price is significantly related with only the conditional variance of the residual "e," (GARCH Term) with P = 0.0009. It is evident that volatility in the spot market is relatively low. Extent of volatility in the spot market is about 30% (revealed by the GARCH term); while changes in the price of commodity in Nigeria leads to the appreciation of premium spot price by about %16 as a result of 10% increase in prices domestic commodity exported while a 1% increase in goods and services consumed locally is as a result of about 7% volatility in crude oil spot prices (that is, spot prices of commodity derivatives). This is in line with inflationary theories which asserts that inflation can be transferred from abroad most especially in developing countries that engage in heavy commodity trade i.e., crude oil. However, this is a co-integrating result.

Causal relationship between oil price and commodity price volatility Granger causality tests between BOP and ECPI			
Null hypothesis	**Observe**	**F=stat.**	**P**
BOP does not granger cause ECPI	142	3.94300	0.0216
ECPI does not granger cause BOP		0.10629	0.8992

Decision rule: If F-tabulated is greater than F-calculated at 5% level of significance then we reject the null hypothesis and if otherwise, we do not reject. From the causality result above we can see that there is a unidirectional causality between both variables because at 5% level of significance, the F-calculated (3.94) is greater than the F-tabulated (3.89) so we do not reject the null hypothesis that BOP does not granger causes ECPI but ECPI granger cause BOP with F-calculated of 0.106. This non causality from spot prices of commodity derivatives (where Brent oil price is a proxy) to export CPI (ECPI) in Nigeria may be as a result of crude oil quota allocation

Figure 1: Conditional variance of consumer price index (consumer price volatility) and Export Consumer price index (exchange rate volatility)



by OPEC (which serves as a hedge against erratic behavior in prices, except in periods of oil glut due to war, democratization, and other internal insurgences in Oil producing nations) and rise in the Financialisation of the international commodity market in the 2000s.

Granger causality tests btw BOP and CPI

Null hypothesis	Observe	F=stat.	P
CPI does not granger cause BOP	142	4.1019	0.0186
BOP does not granger cause CPI		1.2102	0.3013

The result show a unidirectional causality from BOP to CPI (spot price granger causes CPI), that is since F-tabulated (3.94) > F-calculated (1.21), we reject the null hypothesis which says that BOP does not granger cause CPI. This is due to the fact that crude oil prices in Nigeria has a significant impact on domestic consumer prices of goods and services consumed by households due to its price transmission mechanism and the Dutch disease syndrome in the country. This corresponds to model of inflation volatility in Nigeria (Babatunde and Sanni, 2012; Adamgbe, 2003).

5. SUMMARY, POLICY RECOMMENDATION AND CONCLUSION

This work set out to look at the relationship between volatility in commodity prices (international and domestic) and spot prices of commodity derivatives in the international commodity market (i.e., NYMEX). The ARCH, AR(1) and exponential GARCH (EGARCH) (1, 1) model were used and we found out that only domestic consumer prices exhibit volatility clustering and CPI and ECPI shows volatility of 38% and 100% respectively. Also, the volatility in spot prices is significantly explained by export CPI by 16% and there exist unidirectional causal relationship moving from ECPI to international spot (oil) prices. This is as a result of the fact that commodity derivatives markets are reflections of physical commodity trading going on in the country concerned. While 1% increase in prices of goods and services demanded by Nigerian households leads to or is as a result of 7% volatility of spot prices, while there is unidirectional causality from BOP to CPI.

Also, we see that volatility in commodity prices is high (on the average) which creates a need to hedge against risk and loss. It also reveals the unique behavior of the price of oil commodity and its value-deterministic role on other commodities in Nigeria revealed by the overall significance of the regression model (84%). Furthermore, we found through the arch regression family that domestic and international commodity price dynamics average at 68.6 and 109.1 which gives insight in the management of inflation and benchmark insight for forecasting by government and private individuals in Nigeria i.e., drawing of national budget. In addition, the co-integrative behaviour of commodity prices provides useful insight on the multivariate relationship between prices and their fundamental in the long run (Diba and Grossman, 1987).

We therefore recommend that, given the presence of volatility clustering in both international and domestic commodity prices it is pertinent to note that risk in commodity trading can be curbed by a viable trading in commodity derivative in other to hedge against risks both in the long run and short run. Although the Abuja commodity derivatives market was established in 2001 but till today it has not been in operation. Also, Proper maintenance of commodity reserves in the international commodity market will also help to boost the returns of both investors and government in the commodity derivatives market. This is evident in the fact that nations trading in the international commodity market keep commodity reserves in other to regulate prices in the spot and futures market.

In all, from the analysis carried out we conclude that volatility in the spot market is largely determined by fundamental factors of demand and supply and financialization by both government and individuals. As such volatility of spot prices of Nigerian commodity is characterized by sudden shocks which cannot be largely explained by commodity price dynamics alone but a combination of fundamental and financial factors that exist in the international commodity market. Though volatility clustering has been widely observed empirically, there is a paucity of theoretical explanations for this phenomenon (Shiller, 1989). In the case of agricultural and oil commodities, Beck (1993) showed that the storage model can induce ARCH (1) effects in prices. From this work, it is pertinent to note that, household commodity prices do not contribute to the volatility in spot prices but spot price (oil) contributes to its volatility which precipitates volatility clustering which has implication for domestic inflation. We also anticipate the possibility of inflation being transferred from abroad (although this would have been further explained by import CPI), given the price behaviour of prices traded in the international commodity market. While the granger causality relationship reveals underling relationship between Nigeria and the global market place.

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