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RESEARCH ARTICLE

OIL PRICE VOLATILITY AND INFLATION LEVEL IN NIGERIA: AN EXPONENTIAL GARCH APPROACH

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Abstract

Over the years, expenditures of public and private sectors are regulated by the activities in the oil and gas industry. The budget of Nigeria is hinged on the international price of crude oil and any shock on oil price affects the general activities in the country. With quarterly data from the period of 1981Q1 to 2020Q2, the study uses an exponential generalized autoregressive conditional heteroscedasticity approach to examine oil price volatility and inflation level in Nigeria. An augmented Dicky-Fuller unit root test and bound test cointegration approach were used to test for stationarity and existence of long run association among the variables respectively. The study found that negative shocks in real oil price affects the volatility of the inflation level. Also, it was observed that aside real oil price volatility, interest rate and real gross domestic product volatilities affect the volatility of the inflation level. The study therefore recommends among other things that policies meant for diversification of Nigerian economy in areas like industries and agriculture should be adopted to reduce high volatility of the inflation level.

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Introduction:-

The price of oil just like most commodities is affected by the forces of demand and supply. Oil is consumed by most economies and as such, any slightest increase or decrease in the price of oil sends shocks across the globe. The outbreak of fourth Middle East War in 1973 became the powder hose of first oil crisis and provided the members of OPEC with a perfect opportunity to recover the oil pricing power (Lingyu, 2012). The dependence of the Nigerian economy on revenue from oil sales for its annual budgeting and expenditure invariably implies that the government will be under-funded if the oil price shrinks.

Therefore, imposition of direct or indirect tax on the citizens as a panacea for financing its budget has its effect on the economy. Indirect tax especially on fairly elastic, inelastic or perfectly inelastic commodities increases the market price of goods. Movements in oil prices have been fingered as the cause of recessions in some countries. Greenberg (2016) argued that a sharp rise in oil price, as happened in 2007 – 2008 can push economies into recession.

Fluctuations in oil price can be attributed to certain factors, both economic and non-economic. The high price of oil between 1974 to 2010 has been linked to the political unrest in the Middle East during this period. The Middle East has the highest oil producing countries, so in 1974 when the political unrest broke out in that region, the oil market witnessed a supply shock, and has to turn to other oil exporting countries outside the Middle East like Russia and Venezuela. "Prior to the war, Anwar Sadat, who had succeeded Nasser as the president of Egypt in 1970, had convinced the Faisal of Saudi Arabia to use the oil weapon (cutting exports) against countries supporting Israel"

(Rasoul, 2015). Implying that oil scarcity was used as a weapon of war. This action marked the genesis of oil price crisis in the globe. This created a gap in oil supply which caused oil scarcity and the price subsequently jumped. Oil exporting countries including Nigeria was at the gaining end of the 'first oil crisis' (as it was often called).

However, the inflation level in Nigeria has soared high in recent time. In the report of NBS (2020), it was evident that inflationary rate in August and September stood as high as 13.22 percent and 13.71 percent respectively. This was against March, 2018 inflation rate of 13.34 percent. The figure in September, 2020 recorded about 3.7 percent growth from what it was in August, 2020. Oil price impact on the general economy through its effect on the budget (Aigheyisi, 2018). However, fluctuations in oil price would likely affects the national budget and businesses.

Literature Review:-

The consistent rise and fall in the business cycle of virtually all the countries in the world has forced economists to consistently question why economies shrink. Economists wants to know the cause of global recessions. They want to know the role oil play in various economies. They want to ascertain if movements in price of oil raise uncertainties in the economies of the trading countries. Frank Knight described uncertainty as a situation with unknown probabilities.

Empirically, Abraham (2016) researched on the effect of crude oil price movement on the Nigerian stock market and the role of exchange rate as countercyclical policy tool using an autoregressive distributed lag model, he found a positive relationship between oil prices and the stock market. Similarly, Musa (2015) worked on the impact of oil price fluctuation on the Nigerian economy using Structural Vector Autoregression (SVAR), he found that oil price shock has a long run impact on economic growth.

Investigating on the consequences of oil price volatility on the growth of Nigerian economy, Oriakhi, Iyoha and Osaze (2013) employed VAR methodology on quarterly data within the period 1970 to 2010. The study shows that among the variables employed, oil price volatility impacted directly on real government expenditure, real exchange rate and real import, while impacting on real GDP, real money supply and inflation through other variables, notably real government expenditure. This shows that oil price changes determine government expenditure level, which in turn determines the growth of the Nigerian economy. This result seems to reflect the dominant role of government in Nigeria. In another study by Alhassan and Kilishi (2016), GARCH model and its variant (GARCH-M, EGARCH and TGARCH) was used with daily, monthly and quarterly data to investigate the effects of oil price on macroeconomic volatility in Nigeria. The study finds that all macroeconomic variables considered are highly volatile and the asymmetric models out-performed the symmetric models and oil price is a major source of gross domestic product, interest rate and exchange rate volatility in Nigeria. The study therefore recommends the diversification.

Rolle and Uffie (2015) researched on the direct and indirect impact of oil price volatility on the Nigerian economy. The indirect impact tries to measure the effects of oil price shock on selected macroeconomic variable through public expenditure while the direct impact tests those variable directly on oil price volatility. The study used a vector autoregression model and dynamic simulations of forecasting error variance decomposition in addition to pair wise granger causality. The study found that oil price volatility stimulates most macroeconomic variables in Nigeria including public expenditure. Lillien (1982) formulated the dispersion hypothesis notifying asymmetric relationship in oil shock. His argument was based on the fact that oil price fluctuation affects the equilibrium allocation across various sectors. Explaining this point further, Lillen argues that an increase in oil price creates bottleneck in the sector that rely on oil for production while a reduction in oil price will lead to expansion in such sector.

Also, Hamilton (1983) established that a negative relationship exists between oil price increase and economic growth. In his work, he argued that oil shocks played vital roles in some U.S. recessions before 1972. Hamilton's work gave rise to a lot of research in this area by lots of economists. Hooker (1996) also reported that oil price fluctuations significantly affect the United States economy. This was shown by a 10% increment in oil price which resulted to 0.6% less growth in the last two quarters of the oil shock.

More researchers like (Mork ,1989), (Lee, Ni &Ratti, 1985) and (Hamilton ,1996) conducted a causality test between both variables. This was to establish the fact that oil price fluctuation granger-cause the United States economy. The result obtained confirmed this though to some extent. They discovered that oil price granger cause U.S economy before 1973 but does not granger cause it (from 1973 to 1994) in the long run. Jinenez –Rodriguez

(2004) and Hamilton (2004) also argued based on their research that a non-linear relationship exists between oil price and the U.S economy. Gounder&Barlect (2007) discovered that oil price shocks have effects on inflation and exchange rate. They also presented evidence showing that a direct link exists between net oil price shock and economic growth in New-Zealand. The study conducted by Jin (2008) on two big oil importing countries (Japan and China), shows result that does not depart from expectations. It was observed that oil price increase retards economic growth on both countries as the GDP of Japan dropped to 1.6% in 2007 from 2.5% in 2006 owing to the oil crisis that period.

However, there have been a contradicting empiric on whether oil price fluctuation impact on growth. Researchers like Korhonen and JuruiKkala (2007), Zalduendo (2006), Koranchelian (2005) and Mongardum (1998) argued that most economies appreciate or respond positively to oil price fluctuations. On the contrary, Akram and Hotler, (1996), Bjovik,Mork and Uppstad, (1998), Bjonland and Hungnes (2008) and Akram (2000) show that oil price fluctuations have no significant relationship the overall activities in an economy. Serven and Solimano (1993) discovered that fluctuations of oil prices are damaging to the non-oil sector and to capital formation. In 2006, Bagella provided evidence that such fluctuation has negative impact on per capital income.

Nigeria is the second largest oil exporting country in Africa and the 10th largest in the world with a production level of over 2 million barrels per day. Nigeria has been at the gaining end of the oil crisis from the first oil shock of 1973. These oil shocks have positively affected the Balance of payment of the nation and have expanded her foreign reserve portfolio tremendously. Between 2000 to 2008, Nigeria experienced a stable exchange rate with GDP growth rate of almost 5.1% per annum CBN (2008). However, the “resource course syndrome” as proposed by Elanshary, Bradley and Joutz (2005) seems to have affected Nigeria. After decade of massive influx of foreign revenue through oil exports, Nigeria could not sustain a single refinery and end up importing back the oil they exported.

Methodology and Data:-

The study of volatility has been modelled by different authors in different ways. Some others adopted GARCH and VAR-impulse response. Nelson (1991) pointed out some limitations of the GARCH models. First, the GARCH model, by assumption, cannot handle the negative correlation between future values and current values. Second, the GARCH model may over restrict the dynamics of conditional variance by parameter restrictions. Third, the GARCH model makes it hard to interpret whether shocks of conditional variance continue or not. On the bases of these shortfalls of GARCH, Nelson (1991) proposed the use of Exponential Generalized Autoregressive Conditional Heteroscedastic (EGARCH) model. Thus, this study will make use of EGARCH to determine the impact of past information of variables on the dependent variable.

In the light of the limitations of the GARCH model, this study adopts the Exponential Generalized Autoregressive Conditional Heteroscedastic model (EGARCH) to examine the effects of oil price fluctuations on the inflation level in Nigerian economy. The study will first ascertain the presence of volatility in the data set, test for ARCH effect, estimate the EGARCH model and then conduct a post estimation test to find out if the ARCH effect still exist or not.

Testing for ARCH effects

In testing for ARCH effect, the study followed the procedures proposed by Engle (1982) which begins with the estimation of AR model as specified in equation 1 below;

$$R_t = \beta + \gamma_1 R_{t-1} + \varepsilon_t; \varepsilon_t \sim IID(0, \sigma^2) \quad (1)$$

Where R is the rate of return of the series.

Estimated residual is obtained from the result of equation (1), then the squared of the estimated residual is regressed on its lag as follows:

$$\varepsilon_t^2 = \varphi_0 + \varphi_1 \varepsilon_{t-1}^2 + v_t \quad (2)$$

$$H_0: \varphi_0 = 0, \text{ while } H_0: \varphi_1 \neq 0$$

The test statistics for the null hypothesis are F-test and nR2 tests.

The null hypothesis of no ARCH effects is rejected if the probability values (p-values) of these tests are less than 5 percent (0.05). The rejection of Ho implies presence of ARCH effect in the series. Thus, if ARCH effects are present, the estimated parameters should be significantly different from zero (the series are volatile). However, if

ARCH effects are not present, then, the estimated parameters should be statistically insignificant (the series are not volatile).

Modelling the EGARCH

Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) developed by Nelson (1991) captures the asymmetric effects or leverage effects not accounted in the ARCH and GARCH models. This study therefore specifies the EGARCH model as;

$$\ln(\sigma_t^2) = \beta_0 + \beta_1 \left| \sqrt{\varepsilon_{t-1}^2 / \sigma_{t-1}^2} \right| + \omega \sqrt{\varepsilon_{t-1}^2 / \sigma_{t-1}^2} + \theta (\ln \sigma_{t-1}^2) \quad (3)$$

It follows from equation (3) that if the asymmetric effect is present $\omega < (>)0$ implying that positive (negative) shocks of the same magnitude while if $\omega = 0$, there is no asymmetric effect. The Schwartz information criterion (SIC) is used for model selection. The SIC levies the highest penalty on the model for the loss of degrees of freedom. Thus, $SIC(g) = \log(\varepsilon' \varepsilon / n) + g \log n / n$.

Nature and Sources of Data

The data for measuring volatility is required to be of high frequency such as daily, weekly, monthly and quarterly. This study uses quarterly data from 1981Q1 to 2019Q4. The data required in this study is collected from Central Bank of Nigeria Statistical Bulletin 2020Q1.

Following similar approach adopted by Alhassan and Kilishi (2016), the rate of return or growth rate of the variables is computed using the continuous compounded growth rate formula which is given as

$$RGRGDP = \log\left(\frac{RGDP_t}{RGDP_{t-1}}\right)$$

If real oil price is given as ROILP then, return on oil price = $RGROILP = \log\left(\frac{GROILP_t}{GROILP_{t-1}}\right)$

Return on inflation level (RGPRICE) is given as; $RGPRICE = \log\left(\frac{GPRICE_t}{GPRICE_{t-1}}\right)$

In order to arrive at the returns on interest rate, the study use discretely compound growth rate formula. The return on interest rate (RINTR) = $\frac{INTR_t - INTR_{t-1}}{INTR_{t-1}}$

Preliminary Data Analysis

The preliminary data analysis is grouped into descriptive statistics, trend and ARCH test. The descriptive statistics is presented in table 1.

Table 1:- Descriptive Statistic of variables.

	GPRICE	ROILP	INTR	RGDP	RGPRICE	RGRGDP	RINTR
Mean	18.96203	0.001461	1.567580	38702.87	-0.001186	0.004475	-0.104917
Median	12.88300	0.001311	3.690000	24712.08	0.008927	0.005195	0.017571
Maximum	72.72900	0.213720	23.84000	95668.23	0.229039	0.035165	6.512438
Minimum	3.226000	-0.452483	-43.57000	15242.63	-0.593315	-0.012887	-8.094595
Std. Dev.	15.41449	0.073777	13.90861	24004.90	0.092842	0.006681	1.608993
Skewness	1.771350	-1.730339	-0.937901	0.865217	-2.085362	1.044528	-0.430040
Kurtosis	5.169427	12.58553	3.673587	2.376189	14.04033	9.376943	11.98238
Jarque-Bera	111.4523	670.7535	25.65476	21.85203	899.5415	290.8159	525.8556
Probability	0.000000	0.000000	0.000003	0.000018	0.000000	0.000000	0.000000
Sum	2939.115	0.226425	242.9750	5998945.	-0.183822	0.693660	-16.26220
Sum Sq. Dev.	36591.42	0.838227	29791.21	8.87E+10	1.327425	0.006873	398.6840
Observations	155	155	155	155	155	155	155

Table 1 shows the descriptive statistics of the variables in the EGARCH model and it covers the period of 1981Q1 to 2020Q2. It could be observed that the net export (NX) and real gross domestic product (RGDP) recorded the highest mean value. The large differences between the minimum and the maximum values of the variables shows

evidence of significant differences in the trend of the series over the periods of study. Also, the statistical distribution of the series shows that the inflation level (GPRICE), real gross domestic product (RGDP) and return on real gross domestic product (RGRGDP) were found to have positive skewness and hence shows evidence of extreme right tails. However, real oil price (ROILP), interest rate (INTR), return on inflation level (RGPRICE) and return on interest rate (RINTR) were negatively skewed and hence shows evidence of extreme left tails. The kurtosis result shows that with the exception of interest rate and real gross domestic product that are platykurtic, all other variables were found to be leptokurtic. In relation to the distribution of the variables, the Jacque Bera value for each of the variables shows that none of the variables followed a normal distribution. This was evidence as the probability value of the Jacque Bera normality test was less than 0.05 for all the values.

Unit Root Test of the variables

The stationarity test of the variables is tested using Augmented Dicky-Fuller (ADF) unit root test. The null hypothesis is that the series has a unit root and the decision is to reject the null if the t-statistic is greater than the 5 percent critical value.

Table 2:- ADF Unit Root Test.

Variables	Level Form		First Difference		Order of integration
	t-Statistic	5% level	t-Statistic	5% level	
GPRICE	-4.124322*	-2.879966			I(0)
ROILP	-12.29054*	-2.879846			I(0)
INTR	-2.731405	-2.880987	-4.190791*	-2.881541	I(1)
RGDP	-0.316032	-3.439658	-3.869830*	-3.439658	I(1)
RGPRICE	-7.253682*	-2.879846			I(0)
RGRGDP	-4.009440*	-2.879846			I(0)
RINTR	-12.07992*	-2.879846			I(0)

Table 2 shows that GPRICE, ROILP and all the returns variables (RGPRICE, RGRGDP and RINTR) were stationary in their level form while INTR and RGDP became stationary after first difference. Hence, some of the variables were I(0) while some are I(1). This therefore informs the use of Bound testing approach to cointegration as proposed by Pesaran and Shin (2000). The result of cointegration test is presented in table 3.

Table 3:- Bound Test Approach.

Null Hypothesis: No long-run relationships exist				
Test Statistic	Value	K		
F-statistic	9.215260	7		
Critical Value Bounds				
Significance	I0 Bound	I1 Bound		
10%	1.95	3.06		
5%	2.22	3.39		
2.5%	2.48	3.7		
1%	2.79	4.1		

Table 3 shows that the result of Bound test cointegration. The null hypothesis is that there is no long run relationship among the variables in the model. The decision is to reject the null if F-statistic value is greater than the upper bound of the 5 percent critical value. It is evidence from table 3 that there exist long run relationship among the variables in the model.

ARCH Test

The result of ARCH test following the procedure of ARCH LM test proposed by Engle (1982) is presented in table 4. The null hypothesis is that there is no ARCH effect in the model. The decision is to reject the null hypothesis if

the probability values of F-statistic and observed residual are less than 0.05 otherwise, there is no ARCH effect in the model.

Table 4:- Arch Test.

Test	GPRICE	ROILP	INTR	RGDP	RGPRICE	RGRGDP	RINTR
F-Statistic	217.6068* (0.0000)	1330.532* (0.0000)	223.5507* (0.0000)	272895.9* (0.0000)	6.363089* (0.0127)	186.0594* (0.0000)	14.73379* (0.0002)
nR²	91.35102* (0.0000)	140.6187* (0.0000)	92.71534* (0.0000)	156.9109* (0.0000)	6.191037* (0.0128)	85.64879* (0.0000)	13.62188* (0.0002)

Table 4 shows the result of ARCH test. It could be observed that the probability values of F-statistic and observed residual are less than 0.05. This means that the null hypothesis of no ARCH effect can be rejected. Therefore, there is presence of ARCH effect and the study can estimate the EGARCH.

Result of EgarchEstimation:-

The effect of real oil price volatility on the inflation level is presented in table 5. This result shows the initial and return values of these variables.

Table 5:- Estimation of Volatility of oil price and the inflation level.

Variables	EGARCH (1)	EGARCH (2)
Mean Equation		
Constant	-0.010761** (0.0000)	11.29497** (0.0000)
ROILP	0.142418** (0.0000)	1.016254 (0.4866)
Variance Equation		
Constant	-3.946986** (0.0000)	-0.765179 (0.20101)
ARCH (1)	2.113021** (0.0000)	2.074421** (0.0000)
GARCH (1)	0.055676** (0.0460)	0.412242** (0.0099)
ASYMMETRY (1)	0.630858** (0.0000)	0.663141** (0.0000)
ROILP	-5.321851** (0.0058)	-3.709030 (0.2178)
RGRGDP	20.66570 (0.4378)	
GRGDP		0.434220 (1.0000))
RINTR	-0.090662* (0.0794)	
INTR		-0.041624** (0.0001)
ARCH LM Test		
F-Test	0.487428 (0.4861)	0.071353 (0.7897)
nR2	0.492170 (0.4830)	0.072240 (0.7881)
Normality Test		
Jarque-Bera	1.160868 (0.559655)	5.936967 (0.051381)
Coefficient Diagnostic test: Wald Test		
F-statistic	Df	4.060096
		6.007758

	(3, 149)	(0.0083)	(0.0007)
Chi-square	3	12.18029 (0.0068)	18.02327 (0.0004)

Table 5 shows the result of the effect of oil price volatility on the inflation level. It consists of two models. EGARCH (1) is the returns on the variables while EGARCH (2) is the initial variables. It could be observed from the mean model of EGARCH (1) that the real oil price has positive and statistically significant effect on the returns of the inflation level. However, EGARCH (2) shows that the real oil price does not significantly affect the returns on the inflation level. Looking at the variance model, the study shows that both models have ARCH and GARCH effects. In EGARCH model 1, the volatility of oil price was found to affect the volatility of returns in the inflation level. This was found to be negative and statistically significant. It therefore implies that negative shocks in real oil price affects the volatility of the inflation level. The sum of ARCH and GARCH is greater than one for both models. The EGARCH variance process of the series is not mean reverting and hence, the effect of shocks on the inflation level is permanent. The asymmetry coefficients (0.630858 and 0.663141) in the EGARCH (1 and 2) models are positive and significant indicating that positive shocks increase the volatility of inflation level in Nigeria more than negative shocks of the same magnitude. Also, in EGARCH (1), interest rate volatility was observed to negatively affects the volatility of the inflation level. The result of Wald test shows that the volatilities of; real oil price, interest rate and real gross domestic product jointly affect the volatility of the inflation level in Nigeria.

Conclusion and Recommendations: -

The study examines oil price volatility and the inflation level in Nigeria using quarterly data from 1981Q1 to 2020Q2 and an asymmetry model of Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH). The study found that negative shocks in real oil price affects the volatility of the inflation level. Also, it was observed that aside real oil price volatility, interest rate and real gross domestic product volatilities affect the volatility of the inflation level. The study therefore recommends that policies meant for diversification of Nigerian economy in areas like industries and agriculture should be adopted to reduce the volatility of the inflation level.

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