UNDER PEER REVIEW

***Original Research Article***

# EFFECT OF OIL PRICE VOLATILITY ON MARGINAL FIELD PRODUCTION IN NIGERIA

ABSTRACT

This study evaluates the effect of oil price volatility on marginal field production in Nigeria using monthly data from October 2005 to April 2016. ~~This study employed a G~~ARCH model, Johansen co- integration and Granger Causality test to determine whether oil price volatility (independent variable) has an effect on the crude oil production (dependent variable). Result from our GARCH model analysis showed that both the ARCH which act as an econometric tool for gauging volatility and GARCH which measures volatility are significant, ~~that is have predictions on volatility,~~ with the condition Oil price (*loilp*) being the catalyst. ~~The~~ oil price volatility ~~(independent variable)~~ has an influence on the volatility of the crude oil production ~~(dependent variable)~~ of the onshore marginal oil field. ~~From the granger causality test, result~~ showed that Brent oil price volatility granger cause marginal oil field production, that is Brent oil price causes change on the marginal oil field production. Finally result from Johansen co integration test shows that a long term relationship exists between the marginal crude oil production and oil price.

*Keywords: Oil price volatility, Marginal Fields, Generalized Auto Regressive Heteroskedasticity, Johansen co-integration, Granger Causality.*

## INTRODUCTION

This paper evaluates the effect of oil price volatility on marginal fields' production in Nigeria. A case study of onshore marginal field.

## MARGINAL FIELDS DEVELOPMENT IN NIGERIA

Marginal Field was defined by (Egbogah, 2011) as, "any oil discovery whose production would, for whatever reasons, fail to match the desired or established rates-of-return of the leaseholder". The Nigerian Association of Petroleum Explorations (NAPE, 1996) defined marginal fields as, "non-producing fields whose economics is not considered robust enough using conventional development methods under the prevailing fiscal regime". However, from an economic point of view, a marginal field is one that can be developed with marginal profits regardless of the actual size of the oil field, and so require special field development planning and reservoir management strategies in order to yield acceptable returns on investment (ROI) (Chijioke, 2013). In Nigeria, Marginal field is usually referred to a field that has been discovered by major international oil companies who have not developed the field for over 10years ( Kulasingam,2014).

UNDER PEER REVIEW

Different perspectives of marginal fields from various countries

| S/N | COUNTRY | DEFINITIONS |
|---|---|---|
| 1 | Egypt | • Fields with recoverable reserves of about five million barrels of oil (Agiza et al, 1986) |
| 2 | Netherlands | • A gas field is classified as marginal when it holds less than four thousand million of reserves. (Nor Aziah AbdManaf et al, 2014) |
| 3 | United Kingdom | • oil fields with equivalent 20million barrels of oil is classified as ,marginal fields (Ref: plats.com) |
| 4 | USA | • marginal oil wells are those that produce ten barrels per day (Netl.doe.gov) |
| 5 | Nigeria | • A field is regarded as marginal if the field has been left un attended to for a period of ten years. it is usually granted to indigenous companies at the discretion of the president |
| 6 | India | • A field is termed marginal due to various factors ( Geologic, geographic, technological or economic) may not produce enough net income to make it worth developing at a given time. ( Nischal et al, 2012) |
| 7 | Thailand | • A field that is estimated to hold reserves of 15-20million BOE (Moon, 2010) |

Source: Adeogun &Omowumilledare (2015)

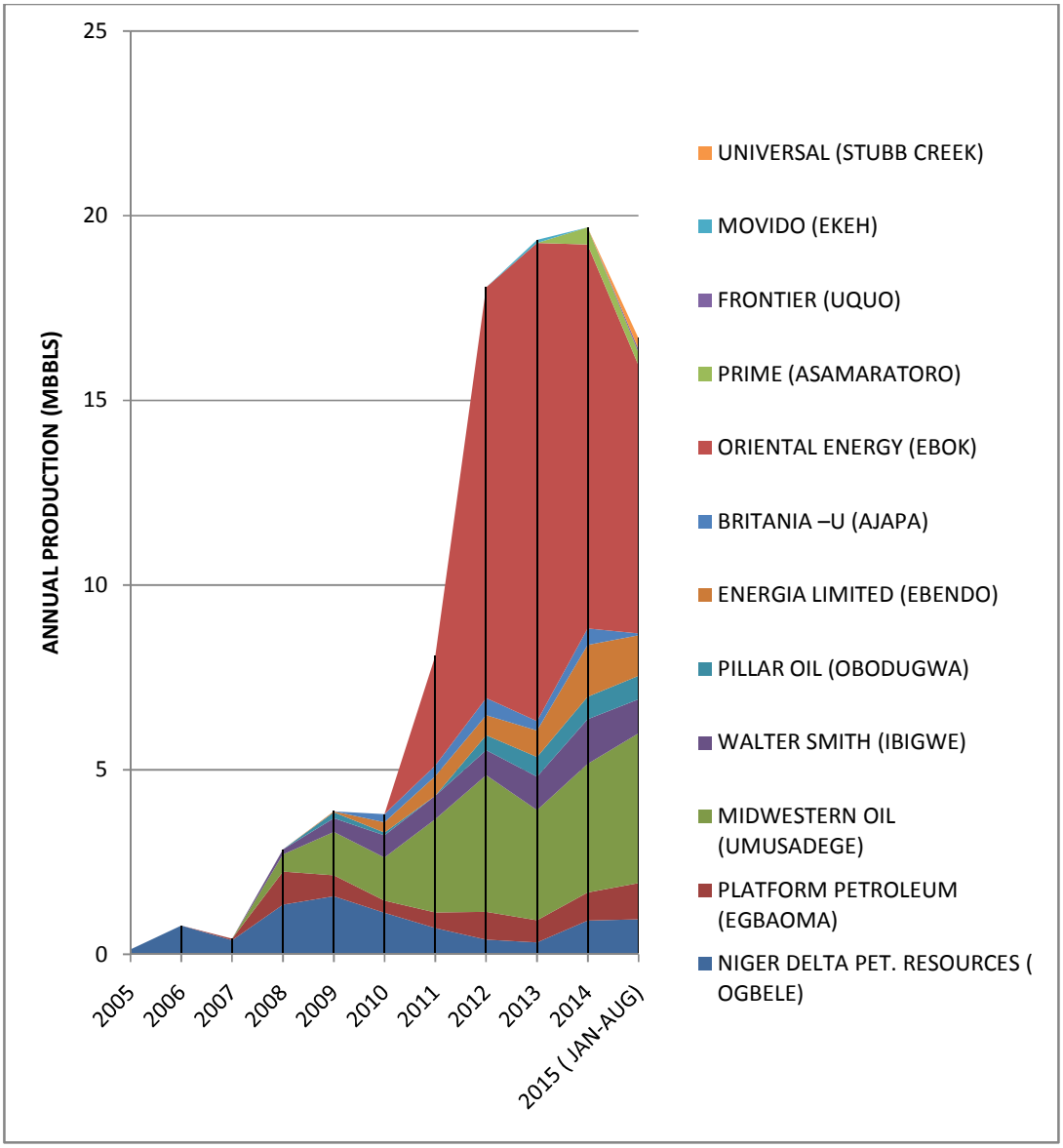
As larger fields become exhausted, countries across the world are striving to find a solution to maximise their energy resource by finding a viable solution for small or isolated fields (ABT oil & gas, 2014). In line with this, Nigeria has been trying to develop its marginal fields in order to grow more reserves of petroleum assets and involvement of local companies in the upstream sector. For over 40 years, Nigeria has witnessed the transformation of the agriculture based economy to oil based. Evolving the local content initiative in this oil-based economy, the Federal Government of Nigeria in 2003, awarded 30 marginal fields of the available 116. The two main objectives of the initiative include the involvement of local companies in the upstream sector of the petroleum industry towards a higher level of indigenization, and growing more reserves of petroleum assets (Idigbe and Bello, 2013). Exploiting these marginal fields would boost the country's daily production of oil. There is a reported huge reservoir of marginal fields in Nigeria conservatively put at over 2.3 billion barrels of Stock Tank Oil Initially in Place (STOIP) spread over 183 marginal fields. (Uche, 2011). Some progress has been made in marginal fields' development as 9 out of the 30 operators have taken their fields to first oil production.

Evolving the local content initiative in this oil-based economy, the Federal Government of Nigeria in 2003, awarded 24 marginal fields of the available 116. The two main objectives of the initiative include the involvement of local companies in the upstream sector of the petroleum industry towards a higher level of indigenization, and growing more reserves of petroleum assets (Idigbe and Bello, 2013).Other reasons include to provide alternative source of funding for exploration of hydrocarbon resources, to encourage capital inflow and to create more employment opportunities for Nigerians (Olorunsola 2012). In other words, it can simply be stated that the Marginal Field Program (MFP) was borne out of the government's initiative to promote local participation of Nigerian oil and gas companies in the upstream sector. The MFP allows only the indigenous oil and gas companies to apply for the operation of the marginal fields. The indigenous companies are allowed to have international partners with equity participation of not more than 40%.

Exploiting these marginal fields would boost the country's daily production of oil no doubt. There is a reported huge reservoir of marginal fields in Nigeria conservatively put at over 2.3 billion barrels of stock tank oil initially in place (STOIP) spread over 183 marginal fields. (Uche, 2011)

UNDER PEER REVIEW

However, by the end of June 2013, less than 30% of the awarded fields are producing petroleum assets, crude oil or natural gas (Idigbe and Bello, 2013) (figure 1)




Source: NNPC Statistical Monthly Bulletin

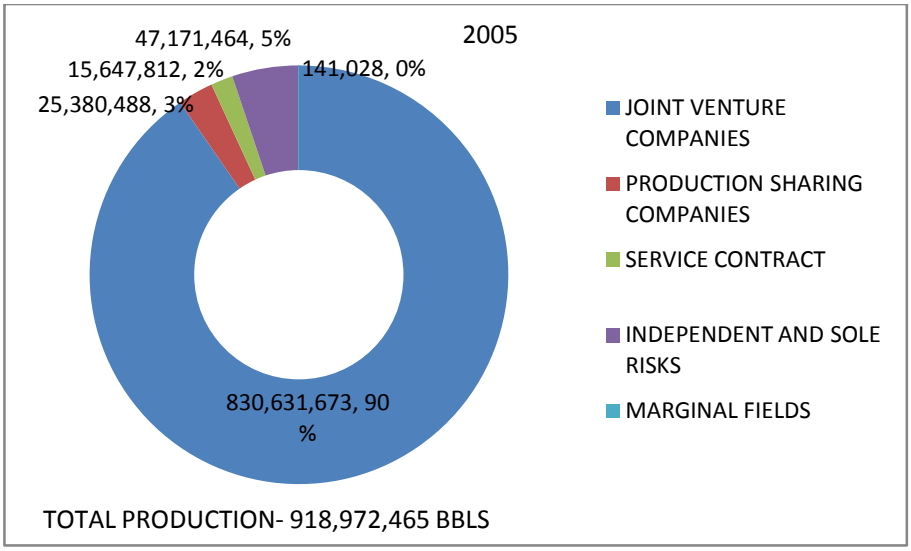
FIGURE 1: NIGERIAN MAGINAL FIELDS PRODUCTION (2005-2015)

According to data obtained from the Nigerian National Petroleum Corporation (NNPC) on oil and gas activities for the month of March 2014, the marginal fields' operators produced 1.645 million barrels of crude oil, representing a daily average of 53,086.26 barrels. This is against a total of 68.367 million barrels produced by all the operations in the sector in the month under review. This translates to an average daily crude production of 2.205 million barrels, showing that the marginal fields' operators are yet to make significant impact on Nigeria's petroleum sector. (Fig 2)

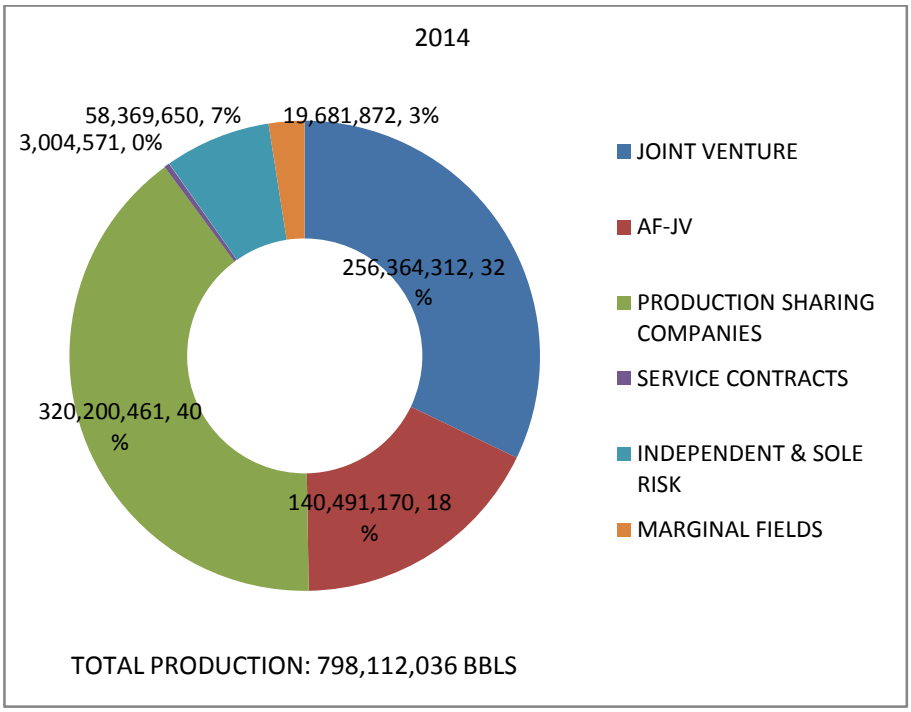
The tables below show the pie chart of Nigerian crude oil production (2005 VS 2014). It shows the performance of Marginal oil fields against the other oil fields operators in Nigeria. figure 3 shows that Marginal field

UNDER PEER REVIEW

contributed 0% to the crude oil production in 2005. Niger Delta Petroleum was the first and only marginal field to start production in 2005 (figure 1). Moving on to 2014 pie chat, it can be noticed that the contribution of marginal field in the oil and gas production has increased from 0% to 3%.




**Source: Drawn with data from NNPC annual statistical bulletin, 2005**
**Figure 2: pie chart of total crude oil production 2005**




Source: NNPC annual statistical bulletin, 2014
Figure 3: pie chart of total crude oil production 2014

In 1995, Goldsmith examined the analysis of the economic effects of new, small marginal oil fields in Alaska covering a twenty year production life. He came to a conclusion that if marginal oil field development is

UNDER PEER REVIEW

successful, it will generate jobs and income for workers, increase states tax base and increase sales for businesses. US law & legal identified parameters that affect marginal fields as environmental concerns, political stability, remoteness, access and of course the price and price stability of the produced liquids and gas which is of great concern to this research. Also, one of the major challenges facing oil companies are investment decision-making associated with the prices of crude oils (Hammad, 2011).

For these reasons it is important to ask the following questions: Does oil price volatility have an effect on the marginal field production in Nigeria? Addressing these questions constitutes the primary aim of the study.

## RESEARCH OBJECTIVES

The primary aim of this study is to analyze the impact of oil price volatility on investment decision making in marginal field development

The specific ~~objectives are~~:

~~I. Investigate the effects of oil price volatility on marginal field production In Nigeria~~

## LITERATURE REVIEW

Majority of the governments of the world have always acknowledged that attracting more businesses will enable them to achieve their national goal of economic and nationwide improvement. This is the reason why the Nigerian government is trying its best to attract many more investors into the oil and gas sector.

Many empirical studies have been carried out to identify the reason why marginal field operations have not been fully successful in Nigeria. ~~The story so far of the marginal fields was investigated by~~ Uche (2011). Chijioke (2013) reviewed the Nigerian marginal oil fields development: status, constraints, prospects and way forward. Osaneku (2013) investigated the challenges and prospects of the indigenous operators in the marginal field. Idigbe and Bello (2013) investigated challenges that confront the local operators and basic roles that will improve the contribution of Marginal fields in Nigeria towards value creation. Adamu et al (2013) provided a perspective on diversification, investment and resource development on offshore marginal field in Nigeria.

The above ~~researches~~ highlighted some of the challenges the marginal oil field operators are facing. These include: legislative and policy bottlenecks, delay in government approval process of marginal fields award, fluctuating assistance from foreign equity partners and local investors, unfavourable tax regime and multiple taxation, local content development policy, delay in finance services, continuous community disturbances, increased asset vandalism and illegal refining of crude oil. Goldsmith (1995) examined the analysis of the economic effects of new, small marginal oil fields in Alaska covering a twenty year production life. He came to a conclusion that if marginal oil field development is successful, it will generate jobs and income for workers, increase states tax base and increase sales for businesses. US law & legal identified parameters that affect marginal fields as environmental concerns, political stability, remoteness, access and of course the price and price stability of the produced liquids and gas which is of great concern to this research. Also, one of the major challenges facing oil companies are investment decision-making associated with the prices of crude oils (Hammad, 2011).

Recently, the price of crude oil has been a major discussion in the news globally. Also, there has been a massive problem of oil price volatility for the developing and developed economies. This has brought about debate on how well to determine the different impact of oil due to the price volatility. The impact of uncertainty on economic performance has been a topic of obvious concern to policy-makers (Aizenman and Marion (1999). Many empirical and theoretical studies have been carried out on impact of oil price volatility on the economy. Many macro economic variables like inflation, exchange rate, GDP and interest rate have been considered in many literatures. ThankGod and Maxwell (2013) investigated the relationship between oil price volatility and economic growth in Nigeria. Results showed a unidirectional relationship from oil price to interest rate and

UNDER PEER REVIEW

exchange rate. Jawad (2013) analyzed the impact of oil price volatility on the economic growth in Pakistan. His results showed that Trade balance and private sector investments have significant effect on GDP and oil price volatility while public sector investment has insignificant impact on Gross domestic production. The impact of oil price volatility on economies of India, China, Malaysia, Indonesia, Philippines and Thailand was investigated by Salim and Rafiq (2013). Wilson et al (2014) investigated the relationship between oil prices and macroeconomic variables in Nigeria and found out that changes in the real GDP are not influenced by oil price volatility in the short run and has no influence on key macroeconomic variables. Ebrahim et al (2014) in their research of the behavioural responses of macroeconomic agents to oil price volatility showed that uncertainty advanced by oil price volatility has several damaging and destabilizing macroeconomic effects. They identified the three main drivers of oil price volatility as characteristics of oil market fundamentals, speculation in the oil derivatives market and in adequacies in oil market data.

Numerous studies have addressed the effect of price volatility on specific economic parameters, the interactions between global macroeconomic performance and oil price volatility. However, as far as I know, there is no current literature that has addressed how oil price volatility affects production which acts as a proxy for the investment decision making in marginal field development. An issue that is relevant at this time as many Nigerian local investors are considering investment opportunities in the marginal fields. Also, Pierru and Matar (2012) in ~~their~~ research that investigated the risk premium that could be attributed to crude oil price by Saudi Arabia authorities recommended that the methodology and a significant part of their considerations can be performed for other resource-rich nations whose domestic income significantly depends on the market price of an exported commodity, like OPEC members. On this ground, this study investigates the impact of oil price volatility on the investment decision making in the development of marginal field.

This study will help investors, investment decision makers, leaders and other members of the governments to understand the impact of oil price volatility on investment decision making in marginal field development. The findings of the study will be beneficial to the business environment, economists, share holders, the government, students and other stakeholders.

**DATA**

The Primary aim of this study is to examine the impact of oil price volatility on marginal field production in Nigeria. The marginal crude oil production (LNDP) would be used as a proxy for investment. A key determinant of investment is oil price (LOILP) which is measured by Brent Spot price. Crude oil price is important because it determines the willingness of people to invest or not. Hence we need to investigate whether crude oil price volatility affects production or not.

The model to be estimated in this study, examines LNDP (a proxy of investment) as a function of crude oil price (LOILP)

$$LNDP = f\ (LOILP)$$

Where LNDP is marginal crude oil production and LOILP is crude oil price.

The type and sources of data that are used in this study is also analysed in this section. To represent the oil price (spot oil price), we chose the Brent crude oil price in US dollars (LOILP). The monthly data was gotten from U.S. Energy Information Administration. The monthly production data was gotten from Nigerian National Petroleum Corporation (NNPC) Monthly Statistical Bulletin . Data Ranges from October 2005 to April 2016.

The Trend of the time series data was analysed using Augmented Dickey- Fuller (ADF) and Phillip- Perron(PP) unit root test and analysis of the long run association between the two variables was done with the Johansen Co-Integration test. The natural log returns of the variables were used so as to fit the model well.

UNDER PEER REVIEW

## METHODOLOGY

### GARCH MODEL

This study will use Exponential Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model to examine the impact of oil price volatility on investment decision making in marginal fields development in Nigeria.

Heteroskedasticity is one of the key problems that require attention when performing time series analysis on oil price given the uncertainty in the movement of oil price. The uncertainty in the movement of oil price is referred to as oil volatility and it can be measured using oil price variance and covariance. Engle (1982) suggested the ARCH (autoregressive conditional heteroskedasticity) model as an alternative to the standard time series treatments. After a period of increased volatility, the period of high volatility that is referred to as volatility clustering continues for a while. The high persistence of volatility is taken into consideration by ARCH model and it has become one of the most common tools for characterizing changing volatility. The ARCH model relies mostly on daily return (usually squared returns) for the modelling of volatility. The shortcoming of the model is that the returns are rather weak signals about the level of volatility.(Hansen & Huang,2012) This particular observation led Bollerslev (1986) to extend the ARCH model into the Generalized ARCH (GARCH) model. The virtue of this approach is that a GARCH model with a small number of terms appears to perform better than an ARCH model with many terms. There is a notion that during a period of falling growth, volatility is likely to rise and during a period of increasing growth it is likely to fall. (ThankGod and Maxwell, 2011).

An ARCH model is a stochastic process with autoregressive conditional heteroskedasticity. They are simple models that are capable of describing a stochastic process which is locally non stationary but asymptotically stationary. If the stochastic process exhibits volatility, then the ARCH models are useful. It has been applied to many areas of the economies like stock returns, foreign exchange rate and the interest rate. The variance at time t depends on past values and it is characterized by a certain number of parameters. An ARCH (p) model is defined by

$$y_t \mid \psi_{t-1} \sim \mathrm{N}\,(0, \sigma_t^2) \qquad (1)$$

Where $\psi_t$is the information set of all information up to and including time ***t.***

$$\sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \ \dots + \alpha_p \varepsilon_{t-p}^2 = \sigma_t^2 = \omega + \sum_{i-1}^{p} \alpha_i \varepsilon_{t-i}^2 \qquad (2)$$

The variance function can be expressed more generally as $\sigma_t^2 = \sigma(y_{t-1}, y_{t-2} \dots y_{t-p}, \alpha)$ where the unknown parameters $\alpha_0, \alpha_1 \dots \alpha_p$are positive constant. $\varepsilon_t$ is a random variable, with zero mean and variance$\sigma_t^2$. p is the order of the ARCH process.

According to the specification in equation (2) the conditional volatility is assumed to be a moving average of squared innovations. For conditional variance to be positive and well defined the parameters must satisfy the following conditions: $\omega > 0, \alpha_1 \geq 0\ and i = 1, \dots, p$.

ARCH model has it shortcomings and the key among them is that it relies mostly on daily return (usually squared returns) for the modelling of volatility which is rather weak signals about the level of volatility. In order to get good results, ARCH models need very long memories (large p). For this reason, Bollerslev (1986) proposed a Generalised ARCH models (GARCH).

The standard GARCH model allows the conditional variance to be dependent upon previous own lags. The basic structure of the symmetric normal GARCH model is GARCH (p, q). A GARCH model is defined by

$$\gamma_t = \mu + \varepsilon_t$$

$$\varepsilon_t = v_t \sigma_t, v_t \sim N(0,1)$$

UNDER PEER REVIEW

$$\sigma_t^2 = \omega + \sum_{i=1}^{p} \alpha_1 \varepsilon_{t-i}^2 + \alpha_p \varepsilon_{t-p}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-1}^2 \quad (3)$$

Where $\sigma_t^2$ denotes the conditional variance since it is a one-period ahead estimate for the variance calculated on any past information thought relevant. For this model to be well defined and conditional variance to be positive, the parameters must follow the following conditions: $\omega > 0, \alpha_1 \geq 0 \; and \; i = 1, \dots, p, \beta_j \geq 0, for j = 1, \dots, q$.

The unconditional variance is given by

$$\sigma^2 = \omega / \; (1 - \sum_{i=1}^{p} \alpha_i - \sum_{j=1}^{q} \beta_j \quad (4)$$

Therefore, the process $\varepsilon_t$is covariance stationary if and only if $\sum_{i=1}^{p} \alpha_i + \sum_{j=1}^{q} \beta_j < 1$. This is not a sufficient condition for $\varepsilon_t$ to be strictly stationary. Some of the shortcomings of GARCH include the fact that the non-negativity conditions may be violated by the estimated method, since the coefficients of model probably are negative.

The GARCH model can capture the following features associated with any financial time series

I. Volatility Clustering: This happens when large a change is followed by another large change. Also when small changes are followed by another small changes. Successive volatility can be uncorrelated and serially dependent at the same time..
II. Fat Tails: in most cases, returns on assets exhibit a fatter tail curve of observation that the one usually observed in a normally distributed curve. this is called excess kurtoises
III. Leverage effect: decrease in assets returns have a negative impact on the value of equity ownership. Given that long- term debts are usually secured and have priority ownership, any in risk associated with higher volatility is usually bearable by equity shareholders. (Hammed, 2011)

## DISCUSSION OF RESULTS

### Preliminary Analysis of Data

Preliminary analysis was conducted with the aim to determine the normality of the data, the stationarity of our time series data and to determine if we can run an ARCH family model.

### Time series properties of data

### Unit root test

Available data were gotten from October 2005 to April 2016. Each series is tested for the presence of unit root or to test if the variables are stationary or not using Augmented Dickey Fuller and Phillip-Perron tests.

Null hypothesis ($H_o$) - The variables are not stationary (has unit root)

Alternative Hypothesis ($H_1$) – the variables are Stationary (has no unit root).

The results of Augmented Dickey – Fuller and Phillip –Perron tests are reported in table below. The production series rejects the null hypothesis of a unit root for both tests. That is no unit root (stationary at levels) except for the intercept test of the ADF which was not statistically significant at 10%. The oil price series fail to reject the null hypothesis of a unit root. This indicates that the series are non stationary (has unit root) when the variables are defined in levels. By first differencing the series, in all cases, the null hypothesis of non-

UNDER PEER REVIEW

stationarity process is rejected at the 1% significance level. Many literatures find crude oil prices to be I (1) (Ito 2010). Thus to achieve stationarity of data, all series were differenced once.

| | ADF | | | | Phillips-Perron | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Intercept | | Intercept and trend | | Intercept | | Intercept and trend | |
| | Level | First diff | Level | First diff | Level | First diff | Level | First diff |
| *Loilp* (log) | 0.1303 | 0.000* | 0.4015 | 0.000* | 0.2906 | 0.000* | 0.6708 | 0.000* |
| *Lndp*(log) | 0.0798*** | 0.000* | 0.2486 | 0.000* | 0.0015* | 0.000* | 0.0094* | 0.000* |

Note: *, **, *** statistically significant at 1%, 5% and 10% significant level

Author's Computation using EViews 7

**OPTIMAL LAG TEST**

Before we can run our Johansen Co-integration and Granger Causality test, the total number of lag to be used need to be obtained. This was achieved using the VAR estimates on the Eviews
The table below shows the best and suitable lags to be used for any of our system equation model. From all the Criterion, 2 lags is the most suitable to be used.

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -139.7015 | NA | 0.037097 | 2.381537 | 2.428245 | 2.400504 |
| 1 | 68.08804 | 405.1022 | 0.001207 | -1.043496 | -0.903373 | -0.986597 |
| 2 | 83.30947 | 29.16376* | 0.001000* | -1.232092* | -0.998552* | -1.137259* |
| 3 | 84.68023 | 2.580249 | 0.001045 | -1.187903 | -0.860947 | -1.055137 |
| 4 | 87.06601 | 4.410684 | 0.001074 | -1.160773 | -0.740402 | -0.990074 |
| 5 | 88.71436 | 2.991970 | 0.001118 | -1.121250 | -0.607462 | -0.912617 |
| 6 | 90.71016 | 3.555537 | 0.001157 | -1.087566 | -0.480362 | -0.841000 |
| 7 | 93.37200 | 4.652629 | 0.001185 | -1.065076 | -0.364456 | -0.780576 |
| 8 | 98.09933 | 8.104005 | 0.001172 | -1.077300 | -0.283264 | -0.754867 |

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

**COINTEGRATION**

The aim of this model is to determine whether the there is a long term relationship between our two variables.

The results of the Augmented Dickey- Fuller (ADF) and Philips _Perron (PP) tests confirmed that there is an existence of a unit root in our variables. (loilp exhibit a unit root @ level for both ADF and PP tests @ interval and Trend+ Interval. while our lndp only exhibited unit root at level for the ADF test at Trend + interval. This suggests that the series are suitable for co- integration testing. (Hammad, 2011)

This test was done to determine the long run relationship among the two variables. The Johansen test is a test for co-integration that allows for more than one co-integrating relationship, unlike the Engle–Granger method. In our case we are testing for the existence of long- term relationship between oil price and crude oil production of the marginal fields in Nigeria.

Following the approach of the Johansen and Julius (1990), ThankGod and Maxwell (2011). Out of the two likelihood ratio statistics test, the trace statistic and the maxima eigenvalue were considered to determine the

UNDER PEER REVIEW

number of co-integration vectors. The result of the trace test and the maximal eigenvalues of the models are presented below.

Unrestricted Co-integration Rank test (Trace)

| Hypothesized No. of CE(s) | Trace statistics | Critical value @5% | Prob |
|---|---|---|---|
| None* | 19.68 | 15.49 | 0.0110 |
| At most 1 | 3.82 | 3.84 | 0.0504 |

Trace tests indicates 1 co-integration equation at the 5% level.
* denotes rejection of the hypothesis at 5%

Unrestricted co integration Rank Test (Maximum Eigenvalue)

| Hypothesized No. of CE(s) | Max-Eigen Statistic | Critical value @5% | Prob |
|---|---|---|---|
| None* | 15.85 | 14.26 | 0.0278 |
| At most 1 | 3.83 | 3.84 | 0.0504 |

Max – eigernvalue test indicates 1 co-integration equation at the 0.05 level.
* denotes the rejection of the null hypothesis at 5%

**Result:**

Null hypothesis: there is no co-integration among the variable. That is there is no relationship between the variables for Johansen test. Results from both the trace and maximum engeinvalue tests shows that our p-value for 'none' are statistical significant at 5% (p-<5%) this makes us to reject the null hypothesis and accept the alternate hypothesis. In conclusion, our result indicates that oil price and marginal field production are co-integrated. That is as a long term relationship.

**GARCH MODEL**

The study aim of this model is to ascertain if the oil price volatility (*loilp*) causes volatility in the marginal field production**.**

**TEST FOR RUNING AN ARCH FAMILY MODEL**

Firstly to justify if we can run an ARCH family model, the regression analysis was done. It is observed from the residuals of regression analysis; periods of low volatility were followed by periods of low volatility (that is from 2005-2007) and periods of high volatility is followed by periods of high volatility for a prolonged period that is from 2008-2010 (Appendix fig 1). This suggests that residuals or error term is conditionally heteroskedastic and it can be represented by ARCH or GARCH model. That is one big shock or fluctuation has caused another big shock or fluctuation. When this happen for our residual then there are justifications to run ARCH family model. We doubled checked by appointing ARCH test to decide whether to run ARCH family model. This indicates that our P value= 0.0000 is less than 5% which makes it statistically significant at 1%. We can reject our null hypothesis and accept our Alternate hypothesis.

Null Hypothesis: There is no ARCH effect

Alternate Hypothesis: There is ARCH effect.

Result: It indicates that we can run any of the ARCH family models

UNDER PEER REVIEW

**ARCH FAMILY MODEL COMPARISON**

The Akaike Information Criterion (AIC) and the Schwarz Information Criterion (SIC) were used to determine the best model to be used. To know if we should use either the ARCH model, GARCH model, TARCH model or EGARCH model to run our analysis. The guideline followed here indicates that the lower the value of AIC and SIC the better the value. Thus our aim is to find the model with the lowest AIC and SIC to run our analysis. From the mean equation we have extracted residuals and used the residual to estimate variance equation. ARCH family equation usually has two parts 1. Mean equation and 2. Variance equation.

| ARCH(5,0) | | GARCH(1,1) | | TARCH | | EGARCH | |
|---|---|---|---|---|---|---|---|
| AIC | SIC | AIC | SIC | AIC | SIC | AIC | SIC |
| 1.44 | 1.61 | 1.43 | 1.57 | 1.46 | 1.59 | 1.46 | 1.59 |

From the table above, the GARCH model exhibits the lowest AIC & SIC which makes it the best model to run our analysis. The next stage is to run the diagnostic test on GARCH to check whether the model has fulfilled all the conditions to run the model.

**Diagnostic test 1**: Correlogram of Standardized Residuals Squared
Objective: To investigate whether our model has serial correlation or not (Appendix table 1)
Null hypothesis: There is no serial correlation
Alternate hypothesis: There is serial correlation

Result: All our P-value is more than 5% meaning we cannot reject null hypothesis but accept null hypothesis that there is no serial relationship

**Diagnostic 2**: Heteroskedasticity test
Objective: To Investigate whether our model has ARCH effect or not.

Null hypothesis there is no ARCH effect
Alternate Hypothesis: There is ARCH effect.

Result: Our P-value is 83.7(Appendix table 2) this is above 5% so we would accept null hypothesis meaning there is no ARCH effect in the residuals.

Heteroskedasticity Test ARCH

| | |
|---|---|
| Obs *R-Squared | 0.042 |
| Prob. Chi Square | 0.837 |

**Diagnostic Test 3: Normality assumption**

We also tested the series for normality using the Jarque-Bera (JB) test and results are listed in appendix fig1. The JB test indicates whether observations in the selected sample came from a normally distributed population.

Null Hypothesis: Residuals are normally distributed
Alternate Hypothesis: Residuals are not normally distributed.

Result: The outcome of Jarque- Bera and the corresponding P- value

| | |
|---|---|
| Jarque- Bera | 5.518 |
| p- Value | 0.063 |

Our p-value is greater than 5% so we accept the null hypothesis.

Conclusion: After the diagnostic test, our model satisfies the diagnostic test. Meaning that:
1 There is no serial correlation in our model

UNDER PEER REVIEW

2. There is no ARCH effect
3. Our residuals are normally distributed

**GARCH model Result**

| | p-value |
|---|---|
| Mean equation | |
| C | 0.00 |
| Loilp(-1) | 0.00 |
| Variance Equation | |
| RESID(-1)^2 | 0.0436 |
| GARCH(-1) | 0.0000 |

Result:
The variance equation table shows that oil price (independent variable) is not taking part in the model, which indicates the property of a catalyst. Therefore the independent variable (oil price) is acting as the catalyst.

From the mean equation table, since the P-value of the oil price (*Loilp*) is equal to zero, that is $p<0.05$, therefore catalyst or condition is significantly present in the model.

Now from the variance Equation table, the probability of RESID (-1) ^2 [ARCH TERM] is equal to 0.04, that is $p<0.05$, this indicates that volatility can be predicted by ARCH term as its P-value is significant. This simply means that previous month's crude oil production can influence present month's crude oil production.

The probability of the GARCH term, that is GARCH (-1) is equal to zero ($P<0.05$), therefore GARCH term is significantly predicting volatility in the model. Meaning that the previous month's crude oil production volatility can influence this month's crude oil production volatility. In a nutshell crude oil production volatility is influenced by its own ARCH and GARCH factors.

Finally we can conclude that in this model, both the ARCH and GARCH terms have predicted volatility, with the condition Oil price (loilp) being the catalyst. That is oil price volatility (independent variable) has an influence on the volatility of the crude oil production (dependent variable) of the onshore marginal oil field

**GRANGER CAUSALITY TESTS UNDER VAR ENVIRONMENT**
**Objective: To test whether there is a form of causality between our two variables**
This test is used to ascertain whether there is a causation or feedback between variables and to determine the direction of such feedback or causality ( Olayiwola and Okodua, 2009, Ogundipe and Ogundipe,2014). The Granger Causality test was used to determine whether there is any form of causality between variables and if there is what is the direction of such causality.
Granger Causality Test Result

| Null hypothesis | Obs | F-stat | Prob |
|---|---|---|---|
| Lndp does not Granger cause Loilp | 125 | 0.309 | 0.735 |
| Loilp does not Granger cause Lndp | | 2.741 | 0.069 |

The first null hypothesis is that our marginal field production (*Lndp*) does not Granger cause oil price volatility (*Loilp*) the F- Stat and the corresponding p-value was used to ascertain the hypothesis. Results show that we

UNDER PEER REVIEW

accept the null hypothesis because P-Value>5%. This simply means that our marginal field production does not affect the Brent oil price volatility.

The second null hypothesis states that our oil price volatility does not granger cause our marginal field production (*Lndp*). Using the F-Stat and the corresponding P- value, we reject the null hypothesis and accept the Alternate hypothesis which states that oil price granger cause production because our P-value is less than 5%. This explains that Brent oil price volatility has an effect on marginal oil field production.

## CONCLUSION

In conclusion, the econometric findings presented in this study demonstrate that oil price volatility has a substantial effect on production in an onshore marginal fields industry in Nigeria. Our result indicates that oil price and marginal field production are co-integrated, that is having a long term relationship. We also came into conclusion that in this model, both the ARCH and GARCH terms predicted volatility, with the condition Oil price (loilp) being the catalyst, that is oil price volatility (independent variable) has an influence on the volatility of the crude oil production (dependent variable) of the onshore marginal oil field. Finally from the granger causality test, result showed that Brent oil price volatility granger cause marginal oil field production, that is Brent oil price affects the marginal oil field production.

## REFRENCES

ABT Oil& Gas (2014), Economic solutions for marginal fields. *www.abtoil&gas.com/marginalfields-economics/*(accessed 08-06-2014)

Adamu,M.A., Ajienka, J.A. and S.S, Ikiensikimama, (2013), Economic Analysis on the Development of Nigerian Offshore Marginal Fields Using Probabilistic Approach,*Advances in Petroleum Exploration and Development* vol. 6(1), pp.11-21

Adeogun, O. and Omowimilledare (2015), Developing a Frameworl for Maximising Marginal oil and gas field Economics. Society of Petroleum Engineers Annual International Conference and Exhibition held in Lagos 4-6 August, 2015 .

Aizenman, J, and N. Marion (1999), Volatility and Investment: Interpreting Evidence from Developing Countries. Economica, New Series, vol. 66 (262), pp.157-178

Bollerslev, T., (1986). Generalized Autoregressive Heteroskedasticity. Journal of Econometrics 31, 307–327

Chijioke, N. (2013). Marginal oil fields development in Nigeria: status, constraints, prospects & way forward.http://eaglereporters.com/2013/12/07/marginal-oil-fields-development-in-nigeria-status-constraints-prospects-way-forward/(accessed 06,02,2014)

Egbogah E.O., "Onshore/Marginal Field Developments: Challenges, Opportunities and

Prospects for the Future*", presented at 2011 SPE Annual Oloiribi Lecture and Energy*

*Forum, Lagos, Nigeria, June 30*

Ebrahim, Z, Inderwildi, O. And D, King (2014), Macro Economic Impacts of Oil Price Volatility: Mitigation and Resilience, *Front Energy*

Engle, R. (1982) Autoregressive Conditional Heteroscedasticity with Estimates of Variance of United Kingdom Inflation, Journal of the Econometric journal, vol. 50 (4), pp.987-1007

Goldsmith,O.S,(1995). Marginal Oil Field Development: The economic Impact, *Institute of Social and Economic Research, University of Alaska Anchorage*

Hammed, R. (2011). Modelling the Impact of Oil Price Volatility on Investment Decision Making, *theDegree of Doctor of Philosophy at University of Hull*

UNDER PEER REVIEW

Idigbe, K.I, and K.O.Bello, (2013). Sustainable Operation of Marginal Fields in Nigeria: Oportunities, Challenges and Best Practices, *Journal of Emerging Trends in Engineering and Applied Sciences*, vol.4(4), pp. 686-691

Jawad, M. (2013). Oil Price volatility and its Impact on Economic Growth in Pakistan, *Journal of Finance and Economics, vol. 1(4), pp 62-68*

Kulasingan R, (2014). Nigeria's marginal Fields Process, Opportunities, challenges and Stetson hats!*Journal of Financial Nigeria Magazine*, http://www.nigeriadevelopmentandfinanceforum.org/PolicyDialogue/Dialogue.aspx?Edition=219(accessed 20-02-2015)

Nigerian Association of Petroleum Explorationist (NAPE), Marginal Fields: The Issue, *(Nigeria: NAPE, 1996), p.30.*

Nigerian National Petroleum Corporation, 2005. Annual Statistical Bulletin, www.nnpcgroup.com (Accessed 05-05-2015)

Nigerian National Petroleum Corporation, 2014. Annual Statistical Bulletin, www.nnpcgroup.com (Accessed 05-05-2015)

Olorunsola, O. (2012), Emerging Oil and Gas Development Opportunities for Marginal Operators,*ANPPA – PETAN Joint Forum, OTC 2012*

Osaneku, M. (2013), Marginal Field & Indigenous Operators: Challenges & Prospects.*http://nigerianoilgas.com/?p=1081(accessed05-05-2014)*

Pierru, A. and W. Matar, The Impact of oil price volatility on welfare in the Kingdom of Saudi Arabia: implications for public investment decision –making

Salim, R. and S. Rafiq,(2010). The Impact of Crude Oil Price Volatility on selected Asian Emerging Economies

ThankGod, A. and I. Maxwell, (2013). Macroeconomic Impact of Oil Price Levels and Volatility in Nigeria, *International Journal of Academic Research in Economics and Management Sciences*, vol. 2(4), pp. 15-25.

Uche,A.(2011),Marginal Fields- The Story So Far. http://nigerianoilgas.com/?p=509 (Accessed 01-28-2015)

U.S. Energy Information Administration, Europe Brent Crude Oil Price. http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=rbrte&f=D. (Accessed 02-05- 2016)

Wilson, A., David, U., Inyiama, O. and E. Beatrice, (2014), Oil Price Volatility and Economic Development: Stylized evidence in Nigeria, *Academic Journal*, vol. 6(6) pp. 125-133

UNDER PEER REVIEW

Appendix

Table1: Correlogram of Standardized Residuals Squared.

Sample: 2005M11 2016M04
Included observations: 126

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| .\|. \| | .\|. \| | 1 | -0.018 | -0.018 | 0.0433 | 0.835 |
| .\|. \| | .\|. \| | 2 | 0.010 | 0.010 | 0.0573 | 0.972 |
| .\|. \| | .\|. \| | 3 | 0.011 | 0.011 | 0.0730 | 0.995 |
| .\|. \| | .\|. \| | 4 | -0.008 | -0.008 | 0.0819 | 0.999 |
| .\|* \| | .\|* \| | 5 | 0.110 | 0.109 | 1.6850 | 0.891 |
| .\|. \| | .\|. \| | 6 | -0.054 | -0.051 | 2.0746 | 0.913 |
| .\|. \| | .\|. \| | 7 | -0.010 | -0.013 | 2.0876 | 0.955 |
| .\|. \| | .\|. \| | 8 | 0.005 | 0.003 | 2.0905 | 0.978 |
| .\|* \| | .\|* \| | 9 | 0.184 | 0.190 | 6.7803 | 0.660 |
| *\|. \| | *\|. \| | 10 | -0.072 | -0.084 | 7.5076 | 0.677 |
| *\|. \| | .\|. \| | 11 | -0.066 | -0.064 | 8.1252 | 0.702 |
| .\|. \| | .\|. \| | 12 | 0.061 | 0.062 | 8.6589 | 0.732 |
| .\|. \| | .\|. \| | 13 | -0.051 | -0.045 | 9.0316 | 0.771 |
| .\|. \| | *\|. \| | 14 | -0.027 | -0.078 | 9.1335 | 0.822 |
| *\|. \| | .\|. \| | 15 | -0.081 | -0.049 | 10.082 | 0.815 |
| *\|. \| | .\|. \| | 16 | -0.075 | -0.061 | 10.911 | 0.815 |
| .\|. \| | .\|. \| | 17 | 0.055 | 0.033 | 11.359 | 0.837 |
| .\|* \| | .\|* \| | 18 | 0.096 | 0.086 | 12.736 | 0.807 |
| .\|. \| | .\|. \| | 19 | -0.044 | -0.009 | 13.030 | 0.837 |
| *\|. \| | *\|. \| | 20 | -0.078 | -0.067 | 13.953 | 0.833 |
| .\|. \| | .\|. \| | 21 | -0.036 | -0.062 | 14.154 | 0.863 |
| .\|. \| | .\|. \| | 22 | -0.021 | -0.008 | 14.222 | 0.893 |
| *\|. \| | *\|. \| | 23 | -0.071 | -0.074 | 15.003 | 0.895 |
| .\|* \| | .\|* \| | 24 | 0.170 | 0.212 | 19.593 | 0.720 |
| *\|. \| | *\|. \| | 25 | -0.125 | -0.105 | 22.072 | 0.632 |
| .\|. \| | *\|. \| | 26 | -0.024 | -0.072 | 22.166 | 0.680 |
| .\|. \| | *\|. \| | 27 | -0.028 | -0.070 | 22.295 | 0.722 |
| *\|. \| | .\|. \| | 28 | -0.098 | -0.046 | 23.874 | 0.688 |
| .\|. \| | .\|. \| | 29 | 0.045 | 0.009 | 24.209 | 0.719 |
| .\|. \| | .\|. \| | 30 | 0.022 | 0.070 | 24.289 | 0.759 |
| .\|. \| | .\|. \| | 31 | 0.040 | 0.050 | 24.560 | 0.787 |
| *\|. \| | *\|. \| | 32 | -0.179 | -0.190 | 30.027 | 0.567 |
| .\|** \| | .\|** \| | 33 | 0.236 | 0.229 | 39.713 | 0.196 |
| *\|. \| | *\|. \| | 34 | -0.105 | -0.086 | 41.659 | 0.172 |
| .\|. \| | .\|. \| | 35 | -0.007 | -0.018 | 41.667 | 0.203 |
| *\|. \| | *\|. \| | 36 | -0.071 | -0.168 | 42.566 | 0.209 |

Table 2: Heteroskedasticity Test

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.041475 | Prob. F(1,123) | 0.8390 |
| Obs*R-squared | 0.042135 | Prob. Chi-Square(1) | 0.8374 |

UNDER PEER REVIEW

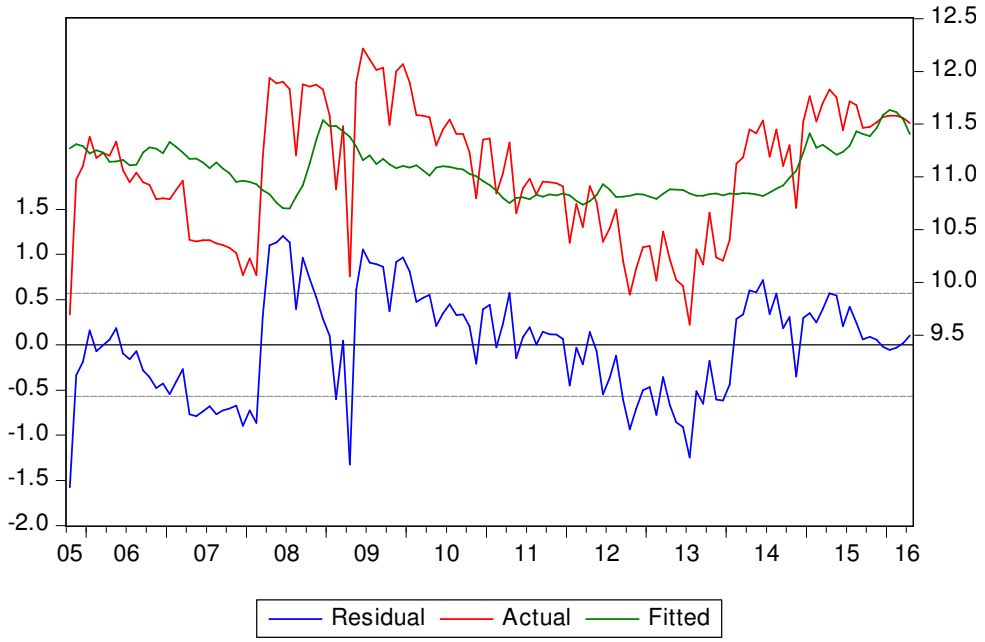
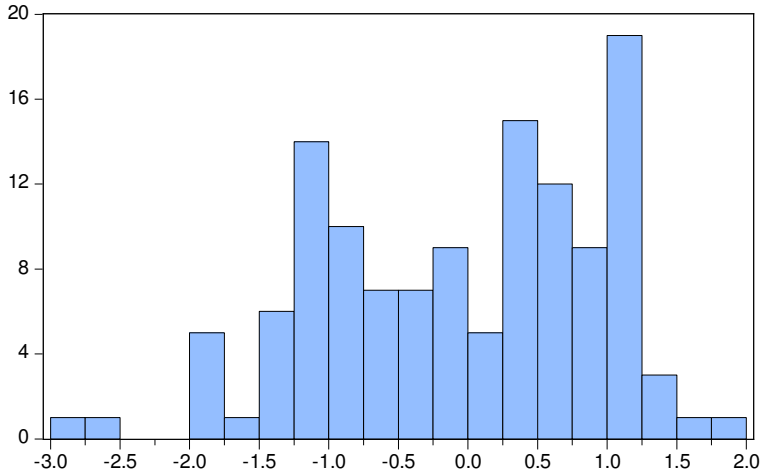



Figure 1: Residual of Regression Analysis




Series: Standardized Residuals
Sample 2005M11 2016M04
Observations 126

| | |
|---|---|
| Mean | -0.049477 |
| Median | 0.107658 |
| Maximum | 1.894450 |
| Minimum | -2.877131 |
| Std. Dev. | 1.002286 |
| Skewness | -0.399095 |
| Kurtosis | 2.356486 |
| Jarque-Bera | 5.518885 |
| Probability | 0.063327 |

Figure 2: Normality Test

UNDER PEER REVIEW

Vector Autoregression Estimates
Sample (adjusted): 2005M12 2016M04
Included observations: 125 after adjustments
Standard errors in ( ) & t-statistics in [ ]

| | LNDP | LOILP |
|---|---|---|
| LNDP(-1) | 0.619457 | -0.022918 |
| | (0.08675) | (0.02090) |
| | [ 7.14083] | [-1.09666] |
| LNDP(-2) | 0.215535 | -0.010765 |
| | (0.08542) | (0.02058) |
| | [ 2.52338] | [-0.52314] |
| LOILP(-1) | -0.090799 | 1.325787 |
| | (0.34888) | (0.08405) |
| | [-0.26026] | [ 15.7744] |
| LOILP(-2) | 0.008844 | -0.407925 |
| | (0.34861) | (0.08398) |
| | [ 0.02537] | [-4.85724] |
| C | 2.192384 | 0.732649 |
| | (0.95393) | (0.22981) |
| | [ 2.29827] | [ 3.18811] |
| R-squared | 0.677740 | 0.937758 |
| Adj. R-squared | 0.666998 | 0.935683 |
| Sum sq. resids | 14.73228 | 0.854995 |
| S.E. equation | 0.350384 | 0.084409 |
| F-statistic | 63.09260 | 451.9873 |
| Log likelihood | -43.72526 | 134.1935 |
| Akaike AIC | 0.779604 | -2.067097 |
| Schwarz SC | 0.892737 | -1.953964 |
| Mean dependent | 11.06906 | 4.381049 |
| S.D. dependent | 0.607185 | 0.332834 |
| Determinant resid covariance (dof adj.) | | 0.000875 |
| Determinant resid covariance | | 0.000806 |
| Log likelihood | | 90.46942 |
| Akaike information criterion | | -1.287511 |
| Schwarz criterion | | -1.061246 |

Table 3: Vector Auto regression Estimates