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Modelling the Impact of Oil Price Volatility on Investment Decision Making in Marginal Fields' Development in Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author FO designed the study and wrote the protocol. Author OSK carried out the analyses and wrote the first draft of the manuscript. Author FO reviewed the first draft and wrote the final draft. Both authors read and approved the finalmanuscript.

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ABSTRACT

This study investigated the impact of oil price volatility on investment decision making in Marginal fields' development in Nigeria. The study also investigated the relationship between oil price volatility and marginal fields' investment analysis in Nigeria. The marginal fields' crude oil production was used as a proxy of investment analysis. Monthly data from October 2005 to April 2016 was used. The GARCH model, Johansen co- integration and Granger Causality tests were employed. Results showed a significant positive relationship between oil price volatility and crude oil production ($P < 0.05$). Moreover, Johansen's co-integration analysis exhibits co-integration between oil price and oil production indicating long term equilibrium relationship. Finally, Pairwise Granger causality test reveals that oil price Granger causes the uncertainties in the oil production since the p-value is small ($P<0.05$) while there is an absence of an influence of oil production on the price mechanism in the market. This proves that the above cause and effect relationship is unidirectional and not bidirectional. The findings from this study show that the dip in global oil price

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reduces oil production from marginal fields' in Nigeria. This is consistent with the law of supply which states that the lower the price, the lower the quantity supplied and vice versa. Hence, investment in marginal oil field development becomes unattractive. However, the need to diversify and utilise gas from these fields for industrial and domestic purposes instead of flaring becomes an imperative.

Keywords: Oil price volatility marginal fields; generalized auto regressive heteroskedasticity; Johansen co- integration; granger causality.

NOMENCLATURES

ABT OIL AND GAS	*: Now Marginal Field Development Company*
ADF	*: Augmented Dickey- Fuller*
ARCH	*: Autoregressive Conditional Heteroskedasticity*
BOE	*: Barrel of Oil Equivalent*
EGARCH	*: Exponential Generalized Autoregressive Conditional Heteroskedasticity*
GARCH	*: Generalized Autoregressive Conditional Heteroscedasticity*
LOILP	*: Natural Log Return of Oil Price*
LNDP	*: Natural Log Return of Marginal Fields Production*
MFP	*: Marginal Fields Program*
MMBBLS	*: Million Barrels*
NAPE	*: Nigerian Association of Petroleum Explorations*
NNPC	*: Nigerian National Petroleum Corporation*
OPEC	*: Organisation of Petroleum Exporting Countries*
PP	*: Phillip- Perron*
ROI	*: Return on Investment*
STIOP	*: Stock Tank Oil Initially Place*

1. INTRODUCTION

Many governments of the world have always acknowledged that attracting more businesses will enable them achieve their national goal of sustainable economic and social development. In the last 40 years, Nigeria has witnessed the transformation of the agriculture based economy to oil based. Hence, the Nigerian government has been making frantic efforts to attract many more investors in the oil and gas sector; the mainstay of the economy. 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 [1].

It has been reported that a large reserve of untapped oil conservatively puts at over 2.3 billion barrels of Stock Tank Oil Initially in Place (STOIP) exists in about 183 marginal fields' in Nigeria [2]. The development of these marginal fields' would boost the country's daily production of oil. Hence, Nigeria has been trying to develop its marginal fields' through its local content initiative. In 2003, the Federal Government of Nigeria through the marginal fields' programme (MFP) awarded 30 marginal fields' of the available 183. The two main objectives of the initiative include the involvement of local companies in the upstream sector of the petroleum industry towards achieving a higher level of indigenisation, and growing more reserves of petroleum assets [3]. Other reasons include providing alternative sources of funding for exploration of hydrocarbon resources, encourage capital inflow and to create more employment opportunities for Nigerians [4]. In other words, it can simply be stated that the 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 license to operate the marginal fields'. The indigenous companies are allowed to have international partners with equity participation of not more than 40%.

However, the major objectives of introducing the marginal fields' have not been achieved. Firstly, its contribution to increase the total crude production of the country has as not been achieved. In 2014 (11 years after its initiation, the marginal fields' crude oil production only contributed about 3% to the total crude oil produced in the sector. Secondly, its purpose to reduce the unemployment rate in the country has not also been attained because only 12 out of the 30 marginal fields' have started activities in their various fields'. This triggered some study to investigate the reasons why the introduction of the marginal fields' has not met its objectives so far. Many empirical studies have been carried out to identify the reasons why marginal fields' operations have not been fully successful in Nigeria. Chijioke reviewed the Nigerian marginal oil fields development: status, constraints, prospects and ways forward [5]. Osaneku investigated the challenges and prospects of the indigenous operators in the marginal field [6]. Idigbe and Bello investigated challenges that confront the local operators and basic roles that will improve the contribution of Marginal fields' in Nigeria towards value creation [3]. Adamu et al. [7] provided a perspective on diversification, investment and resource development on offshore marginal fields' in Nigeria.

The above researches highlighted some of the challenges the marginal oil field operators are facing. These include: legislative and policy bottlenecks, the delay in the 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 financial services, continuous community disturbances, increased asset vandalisation and illegal refining of crude oil. To the best of the researcher's knowledge, the oil price volatility has not been tested to know its asymmetrical relationship and effect on marginal fields' production (proxy for investment analysis). According to Hammed, one of the major challenges facing oil a company is investment decision-making associated with the prices of crude oil [8]. Estimating the consequences of oil price volatility are relevant in the case of marginal fields' because of its economic sensitivity and especially now that there is a crash in the global oil price. The major problem lies in the fact that marginal fields' investors in Nigeria depend only on oil production. Acording to Marius (2009), GARCH is the most appropriate model to use when one has to evaluate the volatility of the returns of groups of stocks [9]. The appropriateness of the model is seen through a unidirectional perspective of the quality of volatility forecast provided by GARCH when compared to any other alternative model, without considering any cost component. GARCH model was therefore employed to empirically test Brent oil price volatility and marginal fields, crude oil production because of its usefulness to predict and simulate volatilities.

The first objective of this paper is to provide a logical investigation of the impact of oil price changes on the Marginal fields' investment decision (which is measured using crude oil production). Additionally intensity of this relationship will be investigated. It will also try to review the possible consequences and challenges presented by high oil prices for marginal fields' investment.

On the strength of prior studies, this paper is adding some quality work in literature. Therefore the fundamental idea of this study is to examine oil price and investment decision in the marginal fields' development in emerging markets so the evidence is taken from an onshore Marginal fields' in the Niger Delta Region of Nigeria over the period of 2005M10-2016M04. So the problem statement is: "an investigation of the impact of oil price changes on the marginal fields' investment.

There is no doubt that effect of oil prices are boiling questions from last few decades therefore this study grabs the attention of researchers to assess the effects of oil prices on the investment decision in the marginal fields' development in Nigeria.

A lot of studies have been explored on the relationship of oil price and different macro economic variables. But only very paper discuses the relationship on micro economic variables. So there is a gap in literature that marginal field's investment analysis have not studied and observed for said relationship. This study will cover this gap. By using this phenomenon, our first hypothesis leads to:

Hypothesis one: Investment decision in the marginal fields' development in Nigeria reacts negatively to oil price changes.

Algeiri, Salim and Rafiq, ThankGod and Maxwell and Ebrahim et al. [10,11,12,13] studied and supported that oil prices shocks and macroeconomic variables have asymmetric relationship. On the basis of this evidences it will also be tested whether Investment decisionin the marginal fields' development react asymmetrically against oil prices shocks.

Hypothesis two: Asymmetric oil price shocks have an impact on marginal fields' investment decision.

2. BACKGROUND

2.1 Brief Insight into the Marginal Fields Operation in Nigeria

Marginal Field was defined as, "any oil discovery whose production would, for whatever reasons, fail to match the desired or established rates-of-return of the leaseholder" [14]. The Nigerian Association of Petroleum Explorations (NAPE) defined marginal fields' as, "non-producing fields' whose economics is not considered robust enough using conventional development methods under the prevailing fiscal regime" [15]. 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) [5]. Table 1 shows the different perspectives of the definition of marginal fields' in different countries. In Nigeria, Marginal field usually refers to a field that has been discovered by major international oil companies which has not been developed for over 10 years [16].

Fig. 1 shows the total number of producing marginal fields' out of the awarded fields. The Majority of the Marginal fields' is producing crude oil only. Niger Delta Petroleum Resources Company is the only company that started production in 2005. However, as of August 2015, some progress has been made in marginal fields' development as 12 out of the 30 operators have taken their fields to first oil production.

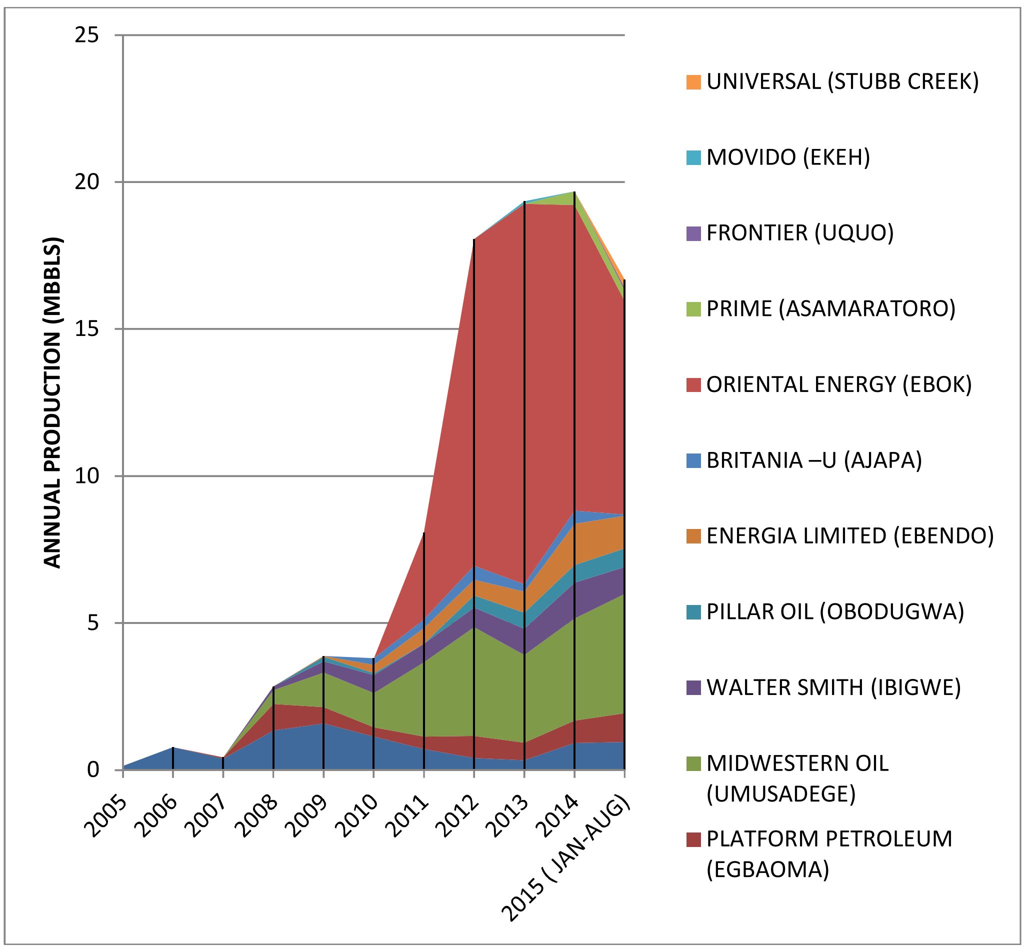


Fig. 1. Nigerian Marginal Fields Production 2005-2015, (MBBLS)
Source: NNPC Statistical Monthly Bulletin

Table 1. 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 millions of reserves. (Nor Aziah AbdManaf et al; 2014).
3	United Kingdom	• Oil fields with equivalent 20million barrels of oil (BOE) 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 unattended 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) which do 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: Modification of Adeogun & Omowumilledare [17]

2.2 The Contribution of Marginal Fields to the Oil and Gas Sector in Nigeria

According to data obtained from the Nigerian National Petroleum Corporation (NNPC) on oil and gas activities for the year 2014, the marginal fields' operators produced 19.7 million barrels of crude oil, representing a daily average of 53,922.94 barrels. This is against a total of 798.1 million barrels produced by all the operations in the sector, which translates to an average daily crude production of 2.19 million barrels, showing that the marginal fields' operators are yet to make a significant impact on Nigeria's petroleum sector (Fig. 2) [18].

Fig. 2 shows the distribution of crude oil produced by the different contractual arrangements during the period 2005 and 2014 respectively. It shows the performance of Marginal oil fields against the other oil field operators in Nigeria. Fig. 2 shows that Marginal field contributed 0% to the crude oil production in 2005. Niger Delta Petroleum was the first and only marginal field to start production in 2005 (Fig. 1). However, by 2014, it can be seen that the contribution of marginal field of oil and gas production increased from 0 to only 3%. This indicates that marginal oil fields are yet to make a significant impact on the oil and gas industry.

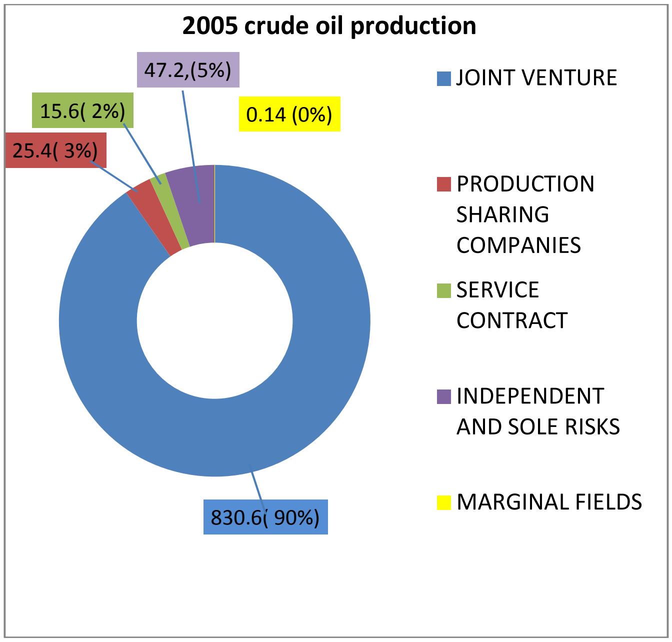
3. LITERATURE REVIEW

3.1 General Overview of Price Volatility

According to the Economics times, volatility is defined as the rate at which the price of a security increases or decreases for a given set of returns. Volatility can be measured by calculating the standard deviation of the annualised returns over a given time period. It shows the range to which the price of a security may increase or decrease. If the prices of a security fluctuate rapidly in a short time span, it indicates volatility is high. If the prices of a security fluctuate slowly in a longer time span, it indicates volatility is low.

3.2 Empirical and Methodological Review of Oil Price Volatility

Many empirical and theoretical studies have been carried out on the 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. Ogundipe and Ogundipe investigated the impact of oil price shocks on investment in Nigeria, covering the period between 1970 and 2011. Multivariate VAR analysis using Granger Causality tests, impulse response functions and variance decompositions have been employed to examine relationships among the variables. The model that was estimated in their study, examined Gross Capital Formation (GCF a proxy for Investment) as a function of interest rate, real Gross Domestic Product (GDP), the official exchange rate, oil price and savings. A Granger causality test which is used to determine whether there is feedback from one variable to another and the direction of such feedback was used to determine whether there is any form of causality between the chosen variables and the direction of such feedback. The results showed a unidirectional causality running from Gross Capital Formation to oil price, meaning that GCF Granger causes oil price and exchange rate was found to Granger cause oil price and savings. Also, a bi-directional causality was found between savings and oil price. Meaning that oil price Granger causes savings and savings Granger causes oil price [19].



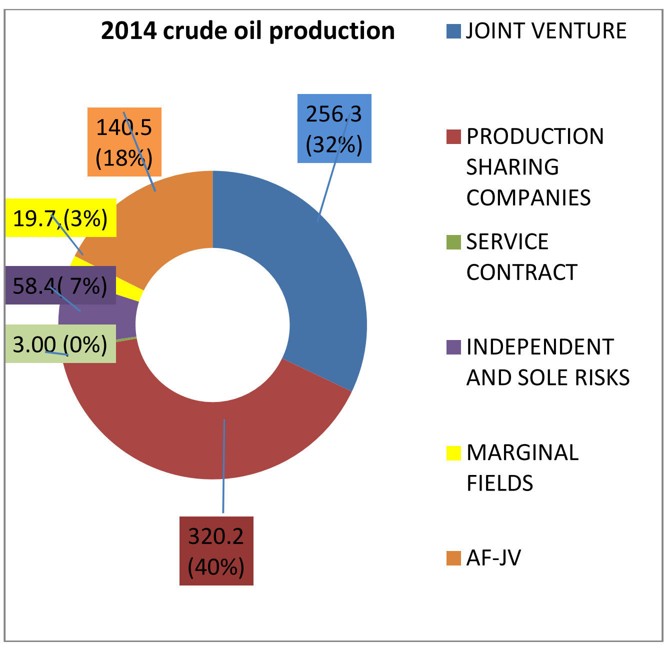


Fig. 2. Pie charts of total crude oil production (mmbbls)
Source: Drawn with data from the NNPC Annual Statistical Bulletin

Hammad investigated the impact of oil price volatility on investment decision making. The study examined whether the prices of non-OPEC crude oils and prices of OPEC crude oils share a common data-generating process. The study covered a range of weekly selected data from 1997 to 2010. Generalized autoregressive conditional heteroskedasticity (GARCH) was employed to empirically test oil price volatility of non-OPEC and OPEC crude oil prices. Johansen Co integration Model and the Engle-Granger Error Correlation Model (ECM) model were applied to test the short and long term relationship between crude oil prices (OPEC and non-OPEC) and stock prices of various oil companies. A panel data approach was finally employed using random and fixed effects to estimate the reaction of non-OPEC and OPEC crude oil prices to events and news items that could possibly affect prices and oil supply. Results suggested that the crude oil price behaviour is not affected by non-OPEC or OPEC affiliation. Based on their empirical analysis, results showed that OPEC production behaviour has an impact on the volatility of crude oil types regardless of its source. His finding suggested that the international oil market is globally integrated market that is able to factor in any possible changes in oil supply behaviour of non-OPEC or OPEC producers [8].

Algieri investigated the relationship between speculation and price volatility. The scope to establish whether speculation drives volatility or volatility drives speculation and whether there are linkages between the two variables were carefully examined. A Granger Causality test was carried out for the period between 1995 and 2012. Results showed that excessive speculation drives price volatility and there is a bilateral relationship between speculation and price volatilities [10].

ThankGod and Maxwell investigated the relationship between oil price volatility and economic growth in Nigeria. Exponential generalized autoregressive conditional heteroskedasticity (EGARCH) and lag-augmented VAR (LA-VAR) models were employed in the study. EGARCH, which is able to demonstrate the existence of asymmetry in volatility with respect to the direction of real growth, was used to estimate the volatility of the oil price and the economic growth, while the LA-VAR model was used to investigate the causal relationship between oil price volatility and economic growth. Results showed a unidirectional relationship between oil price, interest rate and exchange rate [12].

Jawad analysed the impact of oil price volatility on the economic growth in Pakistan. An Econometric technique for Linear Regression analysis was used to analyse the dependency of oil price, GDP, oil demand and supply, public and private sector and trade balance. His results showed that Trade balance and private sector investments have significant effects on GDP and oil price volatility while public sector investment does not significantly impact on Gross domestic production [20].

The impact of oil price volatility on economies of India, China, Malaysia, Indonesia, Philippines and Thailand were investigated by Salim and Rafiq. A Granger-causality test based on standard VAR, generalized variance decompositions and generalized impulse response function was employed to examine the causal relationship between oil price volatility, inflation and output growth in these countries. Results showed that the variables in the model have significant impacts on the future values of each of the variables in the system and oil price volatility impacts output growth in the short run [11].

Wilson et al. investigated the relationship between oil prices and macroeconomic variables in Nigeria. The research adopted the Granger causality to examine whether there is a relationship between oil prices and macroeconomic variables (Real GDP, exchange rate, inflation, interest rate). Ordinary Least Square (OLS) was used to examine the impact of oil prices on the applied macroeconomic indicators. Results showed 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 [21].

Ebrahim et al. in their research on the behavioural responses of macroeconomic agents to oil price volatility showed that uncertainty, advanced by oil price volatility has several damaging and destabilising 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 inadequacies in oil market data [13].

In summary, the relationships between oil price and many other variables have been examined in several developed and developing countries. In this study, we focus on whether these causal relationships exist in Nigeria in respect to marginal oilfield production.

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3.3 Methodological Justification

Over the years, the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) methodology has become quite useful in modelling volatility of economic time series, including consumer price indices [22].

As posited by Engle, this methodology allows a conventional regression specification for the mean function with a variance which is permitted to change stochastically over the sample period [23]. Within this framework, heteroskedasticity is seen as a variance that should be modelled in a time series perspective. Thus, the application of ARCH model introduced by Engle and its generalized extension (GARCH) proposed by Bollerslev in financial modelling have become very popular [23,24].

According to Matei, GARCH is the most appropriate model to use when one has to evaluate the volatility of the returns of groups of stocks. The appropriateness of the model is seen through a unidirectional perspective of the quality of volatility forecast provided by GARCH when compared to any other alternative model, without considering any cost component [9]. GARCH model was therefore employed to empirically test marginal fields' investment decision in the marginal fields' development (crude oil production as a proxy) and Brent oil price volatility crude oil production because of its usefulness to predict and simulate volatilities.

3.4 Empirical Review of Marginal Fields in Nigeria

Ayodele and Frimpong carried out a detailed economic analysis to assess the feasibility of a contractual agreement of a proposed marginal oil field in Nigeria. The economic analysis involved cash flow modelling, project profitability analysis, project sensitivity analysis and risk modelling. Results showed that investing in the development of Nigerian marginal oil fields is a worthwhile option. The result also showed that the proposed agreement leads to a favourable Return on Investment for all parties involved. The project's sensitivity analysis showed that if the combined cost of seismic survey and signature bonus is increased beyond 10%, the project becomes uneconomical. If the price of oil falls below US$18.07, the projects need to be re-evaluated because the discounted payback period will exceed the expected project life. Their risk analysis showed that as NPV increases, so also the risk level associated with such NPV increases too [25].

Akinpelu and Omole examined the economics of Marginal Field Development. The December 2012 NNPC fiscal terms were used to identify the most significant variables impacting the economics. The production variable was treated as one of the main uncertain variables in the probabilistic model because Nigerian Oil and Economic models are usually production dominated. They stated that the main reason why many marginal fields don't make it into development stage in the budget allocation process is economic. Results showed that the field decline rate and initial well productivities have significant impact on the marginal field economics. They recommended that future research should not just limit the variables to production and the well costs variables. Other costs like Jackets and flow line investment, Barge costs and operating costs should be included in the cost management strategy [26].

Adamu et al. [7] provided a perspective on diversification, investment and resource development on offshore marginal field in Nigeria. Net Present Value (NPV), Internal Rate of Return (IRR), Present Value Rate (PVR), Pay Back Period, Profit to Investment Ratio was used to carry out the Economic Analysis which involved project profitability, cash flow modelling and sensitivity analysis. Probabilistic model incorporated was to assess the impact of the uncertainties in the input parameters using Monte Carlo simulation. The deterministic model results obtained from the studies were very impressive. Probabilistically, the certainty of having a positive NPV and good IRR values far above the hurdle rate for investment in Nigeria was obtained. Internal Rate of Return takes care of factor such as high volatility of currency and exchange rate. This implies that inflation rate will hardly affect the profitability of the venture.

Adeogun & Iledare argued that the notion to develop marginal oilfields as a means of increasing oil and gas reserves in Nigeria has not been well defined since inception. Their paper tried to redefine the concept of marginal oilfields in terms of concrete and measurable terms, keeping in consideration recoverable reserves, prevailing fiscal terms and economic conditions.

A comprehensive economic analysis was carried out. A deterministic model was used to determine the profitability of the field and a stochastic model was used to analyse possible scenarios as changes occur in certain input variables with the corresponding output. Results showed that marginal fields are considered a worthwhile investment if adequate incentives are granted by the government. A downward review of signature bonus had little or no impact on the rate of return of investment while reduction in royalty and petroleum profit tax has a positive impact on investment which will make investment in marginal fields more rewarding for investors [17].

According to Goldsmith, in his analysis of the economic effects of new and small marginal oil fields in Alaska, identified five sources of revenues, namely, the corporate income tax, statewide property tax, which makes a small contribution to revenues, full pipeline effect, royalties and potential personal tax contribute the most to the revenue. He came to a conclusion that marginal oil field development in Alaska can generate jobs and income for workers in Alaska, increase in the state's tax base and sales for Alaska businesses [27].

Numerous studies have addressed the effect of price volatility on specific economic parameters and the interactions between global macroeconomic performance and oil price volatility. Also, the price and price stability of the produced liquid/gas has been identified as one of the factors debarring the development of marginal fields. However, no current literature has addressed how oil price volatility affects the investment decision making in marginal fields' development in Nigeria.

3.5 Data

The variables and sources of data used in this study are defined below.

- The marginal crude oil production (*LNDP*) is the total barrels of crude oil produced by an onshore marginal field. The data were gotten from one of the producing marginal fields' in Nigeria.
- A key determinant of investment is oil price (*LOILP*) which is measured by Brent Spot price in US dollars. 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 volatility.

The model to be estimated in this study, examines Marginal crude oil production (*LNDP)* as a function of crude oil price (*LOILP*).

LNDP = f (*LOILP*)

- The monthly oil data were gotten from the U.S. Energy Information Administration & the monthly production data was gotten from the Nigerian National Petroleum Corporation (NNPC) Monthly Statistical Bulletin.
- Data covered the period 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.

4. METHODOLOGY

4.1 Garch Model

This study used Exponential Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model to estimate the volatility of oil prices and of marginal field's crude oil production based on Nigeria from 2005 – 2015. The impact of oil price volatility on investment decision making in marginal field 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 prices. The uncertainty in the movement of oil prices is referred to as oil volatility and it can be measured using oil price variance and covariance. Engle suggested the ARCH (autoregressive conditional heteroskedasticity) model as an alternative to the standard time series treatments [23]. 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 characterising 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 [28]. This particular observation led Bollerslev to extend the ARCH model into the Generalized ARCH (GARCH) model [24]. 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 [12].

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 characterised by a certain number of parameters. An ARCH (p) model is defined by

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

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

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

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 constants. ε_t is a random variable, with zero mean and variance σ_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 its 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. In order to get good results, ARCH models need very long memories (large p). For this reason, Bollerslev proposed a Generalised ARCH model (GARCH) [24].

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

$$\gamma_t = \mu + \varepsilon_t$$
$$\varepsilon_t = v_t \sigma_t, v_t \sim N(0,1)$$
$$\sigma_t^2 = \omega + \sum_{i=1}^{p} \alpha_1 \varepsilon_{t-i}^2 + \alpha_p \varepsilon_{t-p}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-1}^2 \tag{3}$$

Where σ_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:

$$\omega > 0, \alpha_1 \geq 0 \; and \; i = 1, \dots, p, \beta_j \geq 0, forj$$
$$= 1, \dots, q.$$

The unconditional variance is given by

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

Therefore, the process ε_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 ε_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 a large change is followed by another large change. Also, when small changes are followed by other small changes. Successive volatility can be uncorrelated and serially dependent at the same time. 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.

II. Leverage effect: decrease in asset returns have a negative impact on the value of equity ownership. Given that long-term debts are usually secured and have priority ownership, any risk associated with higher volatility is usually bearable by equity shareholders [8].

5. RESULTS AND DISCUSSION

5.1 Preliminary Analysis of Data

Preliminary analysis of data was conducted in order to determine the normality of the data, the stationarity of the time series data and to ascertain whether any of the ARCH family models can be used.

5.2 Time Series Properties of Data

5.2.1 Unit root test for variables

This analysis is based on monthly data of crude oil price and oil production (that is, time series data). This hence requires some specific steps to the analysis. The first step involves testing for the presence of a unit root in each series. As it is known that any model based on time series requires that the series is stationary, as non stationary usually causes deceptive inferences. Researches like ThankGod and Maxwell, Oriakhi and Iyoha and Hammed provided a standard technique to deal with this problem [12,29,8]. This involves testing the variables of an equation for unit root by running the regressions for all the series at both level and intercept and, with constant and trend in the equation. This study employed the Augmented Dickey and Fuller (1979) (ADF) tests and Phillip- Perron tests. Table 2 shows that there is no unit root (that is the variables are stationary at levels) except for the intercept test of ADF which was not statistically significant at 10%. Oil price indicates that the series is not stationary (that is, do have a unit root). But by 1st differencing non-stationarity in the data series of the variables is gotten rid of and stationarity was attained. Many literatures find crude oil prices to be I (1) [30].

Having established that the series is suitable for causality and Co- integrating test that is all the series of the variables is stationary (has no unit root), we proceeded to establish if there is a long term relationship between the two variables (LOILP& LNDP) using Johansen Co integration. After which the Causality test was done to investigate the causal relationship between oil price volatility and marginal field production.

5.3 Optimal Lag Test

In order to run Johansen Co-integration and Granger Causality test, the total number of lags required need to be obtained. This was achieved using the VAR estimates in the Eviews. Results showed that from the entire Criterion (SIC, AIC, HQ), 2 lags is established to be the most suitable for both tests.

5.4 Cointegration

This test was done to determine if there is a long run equilibrium relationship between the two variables. The Johansen test is a test for co-integration that allows for more than one

Table 2. Unit root test

Variable	ADF				Phillips-Perron			
	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

Table 3. Unrestricted Johansen cointegration test

Hypothesized no. of CE(s)	Max– Eigen statistics	Trace statistics	Critical value @5%	Prob.
None*	15.85	19.68	15.49	0.0110
At most 1	3.83	3.82	3.84	0.0504

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

co-integrating relationship, unlike the Engle–Granger method. In this case we are testing for the existence of a long- term relationship between oil price and crude oil production of the marginal fields' in Nigeria (proxy for investment analysis).

Following the approach of Johansen and Julius & ThankGod and Maxwell, out of the two likelihood ratio statistics test, the trace statistic and the maxima eigen value were considered to determine the number of co-integration vectors [31,12]. The Table 3 result of the trace test and the maximal eigen values of the models showed 5% level of significance. This led to a rejection of the null hypothesis and acceptance of the alternate hypothesis. That is, there is a long term equilibrium relationship between the dependent and independent variables, any change in oil price will have a long term equilibrium effect on the marginal field production. Therefore, oil price and marginal field oil production are co-integrated.

5.5 Granger Causality Tests under Var Environment

Table 4 is the result of the Granger Causality test used to ascertain whether there is a causal or feedback between variables and to determine the direction of such feedback or causality. We reject the null hypothesis which states that there is no causal relationship between Brent oil price and marginal fields' crude oil production, and accept the alternate hypothesis which states that there is a causal relationship between the two variables. Furthermore, we tested for the direction of the causality. For the causal direction, we accepted the first hypothesis which states that marginal field production (*LNDP*) does not Granger cause oil price volatility (*LOILP*) (p>10% i.e., not statistically significant). This simply means that our marginal field production does not affect the Brent oil price volatility. We rejected the second null hypothesis which states that oil price volatility does not Granger cause marginal oil field production because the model is statistically significant (P<10%). Thus we accepted the alternate hypothesis (oil price volatility Granger cause marginal fields' production).

In Summary, there is a unidirectional relationship between the two variables.

Having been satisfied that marginal field production is dependent on oil price production, it is important to duel into the behaviour of oil price and marginal field production. ThankGod and Maxwell found out that GARCH model is a good measure of persistent volatility present in oil prices [12].

5.6 Garch Model

The GARCH model was used to ascertain if oil price volatilities contribute to the uncertainties of the crude oil production in the marginal fields.

5.7 Regression Analysis

Regression analysis was carried out to justify the use of an ARCH family model for the analysis. It was observed from the residuals of regression analysis, that periods of low volatility were followed by periods of low volatility (2005-2007) and periods of high volatility were followed by periods of high volatility for a prolonged period (2008-2010). This suggests that residuals or error term is conditionally heteroskedastic and can be represented by ARCH or GARCH model, i.e. one big shock or fluctuation causes another big shock or fluctuation. When this happens to residuals, then the ARCH family model can be used.

5.8 ARCH Effect

Another check was done to confirm this using an ARCH test. The result indicated that P value = 0.0000 i.e. less than 5%, which makes it statistically significant at 1%. The null hypothesis is then rejected and the alternate hypothesis is accepted.

Table 4. 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

Table 5. Akaike Information Criterion (AIC) and the Schwarz Information Criterion (SIC) for ARCH Models

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

5.9 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. The best model is the one with the lowest AIC and SIC. Results as shown in the Table 5 above show that GARCH (1,1) is the best method that fits our model (Table 5).

The next stage is to run the diagnostic test on data to check whether the data has fulfilled all the conditions to run the model.

5.10 Diagonistic Tests

Diagnostic test 1: Correlogram of Standardized Residuals Squared: This was used to investigate whether the observations have a serial correlation or not. The result obtained was greater than 5%. This indicates that there is no serial correlation

Diagnostic test 2; Heteroskedasticity test: Used to test whether our data have an ARCH effect or not. The P-value of the result was 83.7 % (P>5%). This shows that there is no ARCH effect in the residuals.

Diagnostic Test 3: Normality assumption: Jarque- Bera (JB) was used to test whether observations in the selected sample came from a normality distributed population. The result showed that the corresponding P-value of JB test is greater than 5%. This means that our residuals are normally distributed.

In a nutshell, results show that the model satisfies the diagnostic tests. Hence, it's suitable to run the GARCH model.

Table 6. 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

5.11 GARCH Model Result

Table 6 illustrates the estimates of GARCH (1,1) for marginal crude oil production volatility with the effect of oil prices. The result reveals the existence of ARCH and GARCH effects. The parameter of oil price is positive and statistically significant at 1%. This signifies that oil price volatility is a significant determinant of marginal fields' crude oil production volatility in the marginal fields' in Nigeria. Thus the increase in oil price will have a positive impact on crude oil production. This simply means that when there is an increase in oil price, there will be an increase in production, which will have a direct impact on the profitability of the marginal fields' investment. If this happens there will be an increase in investment decision making towards the marginal fields' development in Nigeria. We reject the null hypothesis and accept the alternate hypothesis that states that Brent crude oil price volatility contributes to the uncertainties of marginal fields' investment decision making in Nigeria. Thus, asymmeric oil price volatility has an impact on investment decision making in the marginal fields' development in Nigeria.

6. RECOMMENDATION

This study analysed the effect of the oil price volatility on the marginal field investment in Nigeria using crude oil production as a proxy. On the basis of the findings, considering the destabilizing effects of oil price volatilities on marginal fields' investment, thus some recommendations are put forward to the government and marginal fields' investors;

i. The Majority of the marginal oil fields still flares a lot of their gas due to inadequate provisions of infrastructures and regulations by the government. This led to a loss of 31.8billion Naira in the month of February, 2014. According to the federal Ministry of Environment, there is also an emission of about 17 million tonnes of carbon dioxide (CO_2) yearly which endangers human health and the environment. Many Countries around the world have taken into considerations the benefits of utilising the gas instead of flaring it. These include; conversion into domestic cooking gas, liquefied natural gas, plastic production and many more. So revenue can still be generated from sales of gas, which makes investment in the sector worthwhile. Therefore, the operators of Marginal fields should consider diversification. Government should also increase the penalty on gas flaring so as to reduce the total amount of gas flared. When this is achieved it will bring about a friendlier environment.

ii. Government should consider building infrastructures and investing in refineries. This will reduce the exportation of crude oil and importation of refined products. If this is achieved, government will be the major buyer/market for the crude oil produced by marginal field operators. In a nutshell the fall in global oil price will not have a major impact on the marginal field investment.

If these recommendations are put into considerations, the purpose of initiating the marginal field program will be achieved; i.e., there will be a reduction in the unemployment rate, an increase in the petroleum reserves and an increase in the participation of local investors.

7. CONCLUSION

The study has been able to present that oil price volatility has a long run relationship and has a great impact on investment decision making in the marginal fields' development in Nigeria. This validates the theoretical framework in which this study was based upon. This framework provided an analytical foundation to compile our investigations. This theory's applicability to the Nigeria situation holds as the decrease in the global oil price negatively affects production of the marginal fields' in Nigeria, This is simply due to the fact that Nigerian crude oil is traded in the global market. The findings presented in this study demonstrate that oil price volatility has a substantial effect on the investment decision in the marginal fields' development in Nigeria.The result also indicates that oil price and marginal fields' crude oil production are co-integrated, that is having a long term equilibrium relationship. Also, both the ARCH and GARCH terms predicted volatility, with the condition oil price (*LOILP*) being the catalyst. This simply indicates that oil price volatility contributes significantly to the uncertainties in marginal field's crude oil production. Finally the Granger causality test showed that Brent oil price volatility Granger cause marginal oil field production. i.e. there was a unidirectional relationship.

The main conclusion is that we find a strong support for the hypothesis that is there is a positive relationship between oil price and marginal fields' investment. The oil price should be a major factor to be considered because of its significance in making an investment decision in the marginal fields. This might be borne from the fact that the oil price is the major source of revenue for the marginal fields' investors. Marginal oil fields should not depend solely on crude oil production. The investors in this sector should diversify and utilise all petroleum products effectively and efficiently well This study can be used to show the effect of oil price volatility on the marginal field investment and this will be useful for planning.

Further study can be done considering other pressing issues facing the oil and gas sectors. Issues like how militant insurgencies affect the investment analysis in the marginal fields' development.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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