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22 November 2013

Online at <https://mpra.ub.uni-muenchen.de/51668/>  
MPRA Paper No. 51668, posted 23 Nov 2013 15:49 UTC

# OIL PRICE AND EXCHANGE RATE VOLATILITY IN NIGERIA

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## ABSTRACT

Nigeria being a mono-product economy, where the main export commodity is crude oil, changes in oil prices has implications for the Nigerian economy and, in particular, exchange rate movements. The latter is mostly important due to the double dilemma of being an oil exporting and oil-importing country, a situation that emerged in the last decade. The study examined the effects of oil price, external reserves and interest rate on exchange rate volatility in Nigeria using annual data covering the period 1970 to 2011. The theoretical framework of this study is based on Generalized Autoregressive Conditional Heteroskedasticity modeled by Tim Bollerslev (1986) and Exponential General Autoregressive Conditional heteroskedastic modeled by Daniel Nelson (1991). These models were used to estimate the relationship between oil price changes and exchange rate. Relevant descriptive and econometric analyses were employed. The econometric tests adopted include the unit root tests, Johansen co-integration technique and the Vector Error Correction Model (VECM); the time series property examined shows that all the variables were stationary at first difference. The long run relationship among the variables was determined using the Johansen Co-integration technique while the vector correction mechanism was used to examine the speed of adjustment of the variables from the short run dynamics to the long run. It was observed that a proportionate change in oil price leads to a more than proportionate change in exchange rate volatility in Nigeria; which implies that exchange rate is susceptible to changes in oil price. The study therefore recommend that the Nigeria government should diversify from the Oil sector to other sectors of the economy so that Crude oil will no longer be the mainstay of the economy and frequent changes in crude oil price will not influence exchange rate volatility significantly in Nigeria.

Keywords: Oil Price, Exchange rate, Volatility, Johansen Co-integration,

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## 1.0 Introduction

“There are various evidences, particularly over the post-Breton woods era, pointing to the vital role of oil price fluctuations in the determination of the path of the exchange rate” (Adeniyi et al, 2004). According to Krugman (1983), exchange rate appreciates in response to rising oil prices and depreciates with response to falling oil prices in oil exporting countries, while the opposite is expected to be the case in oil importing countries. According to Englama et al (2010), a volatile exchange rate makes international trade and investments more difficult because it increases exchange rate risk. Exchange rate volatility tends to increase the risk and the uncertainty of external transactions and predisposes a country to exchange rate related risks (Jin, 2008).

According to Adedipe (2004), when Nigeria gained politically independence in October 1960, agricultural production was the main stay of the economy, contributing about 70% of the Gross domestic product (GDP), also employing about seventy percent of the working population and responsible for about ninety percent of foreign government revenue. The initial period of post-independence till mid 1970s witness a fast advancement of industrialized capacity and output, as the contributions made by the manufacturing sector to GDP rose from 4.8 percent to 8.2 percent; this pattern changed as crude oil became important to the world economy. In the words of Englama et al (2010), as crude oil became an export commodity in Nigeria in 1958, following the discovery of the first producible well in 1956; the contribution of oil to the federal government revenue rose from 26.3 percent in 1970 to 82.1 percent in 1974 and in 2008 constituted 83 percent of the federal government revenue, largely on account of increase in oil prices in the international market. The gigantic rise in oil revenue was caused by the Middle East war of 1973. It created extraordinary, surprising and unforeseen wealth for Nigeria and the naira appreciated as foreign exchange influxes offset outflows and Nigeria foreign reserves assets increased (Adedipe, 2004). The economy of Nigeria gradually became dependent on crude oil as productivity declined in other sectors (Englama et al, 2010).

Since the discovery of Oil in commercial quantity, Nigeria has been a mono-product economy. The value of Nigeria’s total export revenue in 2010 stood at US\$70,579 million, while income from petroleum exports of the total export revenue was US\$61,804 million representing about 87.6 percent. The absolute dependence of oil export revenue has accentuated the level of Nigeria economy vulnerability to sudden oil price movements.

Factors such as periods of favorable oil price shocks triggered by conflict in oil-producing countries of the world, rise in the demand for the commodity by the consuming nations due seasonality factors, trading positions etc; enhance Nigeria favorable terms of trade evidenced by her experiences of large current account surplus and exchange rate appreciation. On the converse, when crude oil prices are low, occasioned by factors such as low demand, seasonality factors, excess supply, the Nigeria experiences unfavorable terms of trade evidenced by budget deficit and slow economic growth (Englama, 2010). An example was a drop in the revenue from oil exports during the global financial crisis in 2009. According to, OPEC statistical bulletin (2010/2011), oil export revenue dropped from US\$74,033 million in

2008 to US\$43,623 million in 2009 and the naira depreciated to N148.902 in 2009 from N118.546 in 2008.

This study attempts to examine the extent to which oil price influences exchange rate volatility in Nigeria. Oil price changes directly affects the inflow of foreign exchange into the country, therefore there is a need to investigate its impact on the naira exchange rate volatility; as crude Oil is a key source of energy in Nigeria and in the world. Oil being an important part of the economy of Nigeria plays a strong role in influencing the economic and political fate of the country, crude oil has generated great wealth for Nigeria, but its effect on the growth of the Nigerian economy as regards returns and productivity is still questionable (Odularu 2007).

From the period of the oil boom of the 1970s till now, Nigeria has neglected her strong agriculture and light manufacturing bases in favor of unhealthy dependence on crude oil. New oil wealth has led to a concurrent decline of other sectors in the economy and has fueled massive migration to cities and led to increasingly wide spread poverty especially in rural areas. As a result, Nigeria's job market has witnessed very high degree of unemployment, small wage and pitiable working environments (Adedipe, 2004 and Odularu 2007). Between 1970 to 2000, Nigeria's poverty rate increased from 36 percent to just fewer than 70 percent and it is believed that oil revenue did not seem to add to the standard of living at this time but actually caused it to decline (Martin and Subramanian, 2003).

Oil price fluctuations have received important considerations for their presumed role on macroeconomic variables. Higher oil prices may reduce economic growth, generate stock exchange panics and produce inflation which eventually leads to monetary and financial instability. It will also lead to high interest rates and even a plunge into recession (Mckillop, 2004). Sharp increases in the international oil prices and the violet fluctuations of the exchange rate are generally regarded as the factors discouraging economic growth (Jin, 2008). A very good example is the period of the global financial crisis, the price of oil fell by about two thirds from its crest of \$147.0 per barrel in July 2008 to \$41.4 at end of December 2008. Before the crises, oil price was high, exchange rate was stable but with the dawn of the global financial crisis (GFC) oil price crashed and the exchange rate caved-in, depreciating by more than 20 per cent. Since oil price volatility directly affects the inflow of foreign exchange into the country, there is a need to investigate if it has direct impact on the Naira exchange rate volatility (Englama et al, 2010).

The oil market has been and will continue to be an ever changing arena. This is because oil is so vital to the world economy, it is present in everyone's daily lives and its market is truly global (El-badri, 2011). Thus, it is on this note that this study seeks to examine the effect of oil price on exchange rate volatility and its effects on the Nigerian economy, as well as suggest methods of minimizing the adverse effects it can produce on the economy as a whole.

The study adopts econometric technique in ascertaining the effect of oil price on exchange rate in Nigeria. The GARCH (1, 1) model is used to measure exchange rate volatility and the conditional variance series generates the volatility series from 1970-2011. The Johansen

maximum likelihood test is then used to determine the long run relationship between oil price and exchange rate volatility. The crude oil price and exchange rates are key research subjects, and both variables generate considerable impacts on macroeconomic conditions such as economic growth, international trade, inflation, and energy management. The relationships between the two have been studied, mainly for guidelines of interaction and causality. In past decades, changes in the price of crude oil have been shown to be a key factor in explaining movements of foreign exchange rates, particularly those measured against the U.S. dollar (Huang and Tseng, 2010).

While a considerable amount of studies have dealt with some aspect of the relationship between international oil price and exchange rate, a number of questions still spring to mind namely: Is there a significant link between oil prices and exchange rate determination in Nigeria? Do positive and negative shocks to oil prices volatility have symmetric effect on exchange rate volatility?

## 2.0 Background facts

### 2.1 Oil price movement and exchange rate volatility

Since the ending of the 1940s to the beginning 1970s the international oil price was very steady having only small changes. Then from the early 1970 to the early 1980s the price of oil increased beyond expectation with respect to the rise of OPEC and the disruption in the supply of crude oil. OPEC first exercised its oil controlling power during Yom Kippor War which started in 1973 by imposing an oil restriction on western countries as a result of U.S and the Europe support for Israel. Production of Oil was reduced by five million barrels a day, this cut back amounted to about seven percent of the world production and the price of oil increased 400 percent in six months.

From 1974 to 1978 crude oil prices were relatively stable ranging from \$12 to \$14 per barrel. Then between 1979 and 1980 during the Iranian revolution and Iraq war, the world oil production fell by 10% and caused the rise of crude oil price from \$14 to \$35 per barrel. Increasing oil prices forced leading consumers and firms to adopt a more conserve energy, people purchased cars that could manage fuel and organizations purchased machine that were more fuel efficient (Sharma 1998). Increased oil price also enlarged search and production by nations that were not members of OPEC. Beginning from 1982 to 1985 OPEC wanted to stabilize the price of oil through production of quotas, but safeguarding efforts, global economic meltdown and wrongful quotas produced by OPEC participant countries contributed to the plunging of oil prices beneath \$10 per barrel.

From the Mid-1980s the fluctuations in the price of oil has occurred more frequent than the past. OPEC has continually been trying to influence oil price to ensure its stability through allocation of production quotas to its member countries but has been unable to stabilize it; as OPEC share of the world oil production has fallen from 55 percent in 1976 to 42 percent today. Oil prices matter in the economy in various ways; changes in oil price directly affect transportation costs, heating bills and the prices of goods made with petroleum products. Oil price spikes induce greater uncertainty about the future, which affects households and firms

spending and investments decisions. Also changes in oil prices leads to reallocations of labor and capital between energy intensive sectors of the economy and those that are non-energy intensive sector (Sill, 2009).

## 2.2 Brief History of Oil in Nigeria

The search for oil began in 1908 by a German company named Nigeria Bitumen Corporation, but there was no success until 1955 when oil was discovered in Oloibiri in Niger delta by shell-BP. Nigeria started exporting crude oil in 1958 but in major quantity in 1965, after the establishment of the bonny island on the coast of Atlantic and the pipeline to link the terminal. In 1970, as the Biafra war ends, there was a rise in world oil price and Nigeria benefited immensely from this rise. Nigeria became a member of Organization of petroleum exporting countries (OPEC) in 1971 and the Nigerian National Petroleum company (NNPC) which is a government owned and controlled company was founded in 1977. By the late sixties and early seventies, Nigeria had attained a production level of over 2 million barrels of crude oil a day. Although there was a drop in production of crude oil in the eighties due to economic down turn, by 2004 Nigeria bounced back producing 2.5 million barrels per day, but the Niger delta crisis and the global economy financial crises reduced Nigeria oil production and the world oil price.

The discovery of oil brought in the eastern and mid-eastern regions of Nigeria, this brought hope of a brighter future for Nigeria in terms of economic development as Nigeria became independent, but there were also grave consequences of the oil industry; as it fuelled already existing ethnic and political tension. The tension reached its peak with the civil war and reflected the impact and fate of the oil industry. Nigeria survived the war and was able to recover mainly from the huge revenue gained from oil in the 1970s. The Nigeria gained wholesomely from the nearly 36 months oil boom, the boom generates a lot of fund needed to meet all development need but the oil revenue which was supposed to be a blessing became a curse due to the corruption and the mismanagement of windfall gain from oil. The enormous impact of the oil shock on Nigeria grabbed the attention of scholars who tried to analyze the effect of oil price on economic growth in Nigeria. A set of radical oriented writers were interested in the nationalization that took place during the oil shock as well as the linkages between oil and an activist foreign policy. Regarding the latter, the emphasis was on OPEC, Nigeria's strategic alliance formation within Africa, the vigorous efforts to establish the Economic Community of West African States (ECOWAS), and the country's attempts to use oil as a political weapon, especially in the liberation of South Africa from apartheid. Many people had hoped that Nigeria will become an industrial nation and a prosperous nation from the benefits of oil but they were greatly disappointed when we Nigeria hit a major financial crisis that led to the restructuring of the economy (Odularu, 2007)

## 2.3 Measuring of Exchange Rate Volatility

It is well-known in literature that getting the exchange rate right or maintaining relative stability is important for both internal and external balance and consequently growth in the economy. Exchange rate is the most important price variable in an economy and performs

the twin role of maintaining international competitiveness and serving as nominal anchor to domestic price (Mordi 2006).

Swings or fluctuations in the exchange rates over a period of time or deviations from an equilibrium exchange rate is referred to as exchange rate volatility. Where there is multiplicity of markets parallel with the official market there could be deviations from the equilibrium exchange rate. Volatility over any time period interval tends to increase when supply, demand or both are likely to respond to large random shocks and when the elasticity of both supply and demand is low price volatility tends to be low (Obadan 2006). The exchange rate is subjected to variations when it is not fixed, thus a floating exchange rate tends to be more volatile. Economic essentials affect the level of volatility and the extent to which exchange rate stability is maintained. Favorable economic circumstances and outcome which in turn would appreciate the currency and maintain stability is caused by strong fundamentals (Mordi 2006)

In the vast wide-ranging literatures on exchange rate volatility, there has been no agreement on the appropriate approach for evaluating volatility by economic researchers. The lack of an agreement on this topic echoes a number of factors as different theories cannot provide a definite guidance as to which measure is the most suitable. Moreover, the type of measure to be adopted will depend on the scope of study. The time period over which fluctuations are to be measured, as well as whether it is unrestricted volatility or the sudden movement in the exchange rate parallel to its predicted value needs to be taken into consideration. Finally, in shaping the applicable measure of exchange rate to be used, the level of collective trade flows should be taken into consideration.

The degree to which exchange rates, due to its habitually high volatile state are a source of risk and ambiguity depends on the degree to which movements in the exchange rate are predictable. With hedging, the predictable part can be hedged away so that the cost on trade is minimal. A realistic measure would be to use the forward rate as an indicator of the future spot rate, and indicating the exchange rate risk with the discrepancies between the current spot rate and the earlier period forward rate even though using the forward rate as an indicator is a problem with predicting the future exchange rates adding to the fact that quotations are only existing for major currencies.

McKenzie (1999) believes that there are a number of measures that should be taken into consideration ranging from the structural models to the time series equation making use of the ARCH/GARCH approaches. The standard deviation of the first variation of logarithms of the exchange rate is the most widely used in measuring exchange rate volatility. If the exchange rate is on a steady trend, which could easily be forecasted the result will therefore not be a source of uncertainty. The standard deviation is calculated over a period of one year to point out a short-run volatility and in acquiring long-term variability, a period of five years is used.

Finally, in measuring exchange rate volatility, the importance of currency invoicing is to be taken into consideration. Mostly, trade between two developing countries is not invoiced in

the currency of either country. A standard currency is been used mostly the U.S. dollars is often used as the invoicing currency. It may look like the volatility of the exchange rate between the two trading partners' currencies is not the important volatility to consider however this is wrong. For example, if trade exports from China to Nigeria are invoiced in U.S. dollars, it might look like the Chinese exporters would only care about the changes between the U.S. dollar and the Chinese Yuan, but not between the Nigeria naira and the Chinese Yuan. Nevertheless, any change between the Chinese Yuan and the Nigeria naira holding constant the Chinese Yuan/U.S. dollar rate must mirror fluctuations in the Nigeria naira/U.S. dollar rate. As the latter could affect the Nigerian demand for Chinese exports, changes in the Chinese Yuan/Nigeria naira exchange rate would also affect the Chinese exports to Nigeria even if the trade is invoiced in the U.S. dollar (Ojebiyi and Wilson 2011)

According to Adedipe (2004) the different exchange rate regimes in Nigeria can be classified into different periods relating to vagaries in the international oil market.

i. The Post-Independence Era (1960 – 1971)

The Nigerian currency was pegged at par to the British pound sterling (GBP) using administrative measures, to sustain the parity. The devaluation of GBP in 1967 made Nigeria adopt the US dollar, which was deemed better to support the import substitution industries which depend heavily on net imported inputs. Throughout this period the Nigerian pound sterling was overvalued, inhibiting optimal growth in agriculture and in goods produced for exports.

ii. The Oil Boom Era (1972 – 1986)

During this period the exchange rate moved in the same pattern as the oil prices and the naira remained overvalued as a result of the huge increase in foreign exchange earnings. This currency was anchored to the GBP until, 1972 when the GBP was floated and then pegged to the US dollar. However in 1978, the naira was anchored on a basket of currencies of Nigeria 12 major trading partners. This was changed in 1985 and the Naira reverted to quotation against the US dollars.

iii. The Post – Sap Era (From 1986)

The Naira was subject to a managed float system in a continuing effort to restructure the economy away from oil dependency. The policy of deregulation of the foreign exchange market in 1986 was to show the true value of the naira, this was in the view of boosting oil-non exports. Thus, from N0.89388/US\$ at the end of 1985, the exchange rate weakened to N2.0206/\$ at the end of 1986. This was done in expectation of promotion of non-oil exports and the naira was further devalued in March 1992 by 44% to N17.2984/\$. Devaluation of the naira in other to encourage non-oil export has not produced the desired return. The Exchange rate value of Nigeria is very crucial to the Annual budget, the Gross domestic product (GDP), the level of development, among other things. Therefore, a study on the effect of Oil price on Exchange rate volatility is very important.

### 3.0 Review of literature

Diverse theoretical relationship between oil price and exchange rates have been established in literature (Beckmann and Czudaj 2012). Oil price fluctuations have received significant considerations for their perceived role in macroeconomic variables dynamism. The consequences of large increases in the oil price on macroeconomic variables have been of great concern among economist and policy makers as well as the general public, since two major oil price shocks hit the global economy in the 1970s (Sill 2009). The thought that exchange rate is the most difficult macroeconomic variable to model empirically is debatable. Many papers have suggested that oil price might have a significant influence on exchange rate. The proposition that oil price might be adequate enough to explain all the long run movements in real exchange rate appears to be new (Al-Ezzee, 2011)

Nigeria like other low income countries has adopted two main exchange rate regimes for the purpose of gaining balance both internally and externally. The purpose for this different practice is to maintain a stable exchange rate (Umar and Soliu 2009). A fluctuating real exchange rate as a result of adverse fluctuation stemming from volatile oil prices are damaging to non – oil sector, capital formation and per capita income (Serven and Solimano 1993 and Bagella 2006). The consequences of substantial misalignments of exchange rate can lead to shortage in output and extensive economic hardship. There is reasonably strong evidence that the alignment of exchange rate has a substantial influence on the rate of growth of per capita output in low income countries (Isard 2007).

According to Trung and Vinh (2011) there are two reasons why macroeconomic variables should be affected by oil shocks. First, oil increase leads to lower aggregate demand given that income is redistributed between net oil import and export countries. Oil price spikes could alter economic activity because household income is spent more on energy consumption and firms reduce the amount of crude oil it purchases which then leads to underutilization of the factors of production like labor and capital. Second, the supply side effects are related to the fact that crude oil is considered as the basic input to production process. A rise in oil price will lead to a decline in supply of oil because of the rise in cost of crude oil production which will lead to a decline in potential output.

For various reasons known and unknown, oil price increases may lead to significant slowdown in economic growth. Five of the last seven United States of America recessions were preceded by significant increases in the price of oil (Sill, 2009). A factor discouraging economic growth is sharp increases in the international price of oil (Jin, 2008).

Analysis of the impact of asymmetric shocks caused by exchange rate and oil price variability on economic growth has been a major concern of both academics and policy makers for a long time now (Aliyu 2009). According to Amano and Norden (1998) many researchers suggest that oil fluctuations has a significant consequence on economic activity and the effect differ for both oil exporting countries and oil importing countries. It benefits the oil exporting countries when the international oil price is high but it poses a problem for oil importing countries. According to Plante (2008) theoretically immediate effect of positive oil price

shocks is the increase in the cost of product for oil importing countries , this is likely to reduce output and the magnitude of the depends on the demand curve for oil. Higher oil prices lower disposable income which then leads to a decrease in consumption. Once the increase in oil price is believed to be permanent, private investments will decrease. But if the shocks are perceived as persistent oil is used less in production, the productivity of labor and capital will decline and potential output will fall.

Some researchers have carried out research the issue of oil price and exchange rate further. According Rickne (2009) political and legal institutions affect the extent to which the real exchange rate of oil exporting countries is affected by international oil price shocks. In a theoretical model strong institutions protect real exchange rate from oil price volatility by generating a smooth pattern of fiscal spending over the price cycle. Empirical analysis carried out on 33 oil exporting countries show that countries with high bureaucratic quality and strong and impartial legal system have real exchange rate that are affected less by oil price. Also according to Mordi and Adebisi (2010) the asymmetric effect of oil price changes on economic activity is different for both oil price increase and oil price decrease. Patti and Ratti (2007) shows that oil price increases have a greater influence on the economy than a decrease in oil price.

Empirical research suggesting that oil price serves as a major determinant of real exchange rate has yielded somewhat puzzling results for oil exporting countries (Rickne, 2009). According to empirical works carried out, there has been what appears to be a rather strong relationship between real oil prices and real exchange rates of a number of countries (Plante 2008).

Korhonen and juurikkala (2007) showed that increasing crude oil prices cause a real exchange rate appreciation in oil exporting countries and this is not shocking, since they earn a significant amount from oil exportation. There is also a significant relationship between real oil prices and real exchange rates for oil importing countries; evidence has been seen for Spain (Camarero and Tamant 2002). A study carried out on the Russian economy by Spatafora and Stavrev (2003) confirm the sensitivity of Russia's equilibrium real exchange rate to long run oil prices. Likewise, Suseeva (2010) verified a long run positive relationship between the real oil price and the real bilateral exchange rate against Euro in Russia. Lizardo and Mollick (2010) provided proof that between the year 1970s to 2008, movements in the value of the U.S dollar against major currencies was significantly explained by oil prices. They found that when oil prices group currencies of oil importers such as china suffer depreciation. On the other hand, in net-oil exporters such as Canada, Mexico and Russia increase in oil prices leads to a noteworthy depreciation of the US dollar. But, Akram (2004) finds strong evidence of no linear relationship between oil prices and the Norwegian exchange rates.

Using Blanchard – Quah identification strategy Clarida and Gali (1999) estimate the share of exchange rate fluctuations that is due to the different shocks in oil. Using quarterly data from 1974 to 1992 comparing the United States of America to four different countries (Germany, United Kingdom, Japan and Canada) they found that more than 50% of the variance of real

exchange rate changes over all the horizons was caused by real oil shocks. Amano and Norden (1998) using data on real effective exchange rates for Germany, Japan and United States of America discovered that real oil price is the most important factor in determining real exchange rates in the long run.

An advance in the productivity of tradable relative to non-tradable if larger in other countries could lead to the appreciation of the real exchange rate. This is the Balassa-Samuelson hypothesis formulated by Balassa (1964) and Samuelson (1964). According to Coudert(2004), the Balassa-Samuelson effect is the mechanism by which an appreciation of the real exchange rate occurs owing to changes in relative productivity. We use the real oil price as a representation of the terms of trade and examine the influence of oil price fluctuations and productivity differentials on the real exchange rate given that oil price is the main export good driving the terms of trade in oil exporting countries. In practice, the price of the main exported good is often used as an indicator of the terms of trade (Sossounov and Ushakov, 2009).

Using a panel of 16 developing countries Choudhri and Khan(2004)provided strong evidence of the workings of the Balassa Samuelson effects. Coudert (2004) survey provided evidence that the trend appreciation in the real exchange rate observed in countries of central and Eastern Europe during the early 2000 stemmed in fact from a Balassa effect. The writer noted that even though other factors were just as responsible, the estimated Balassa effect goes some way in explaining the real appreciation.

Kutan and Wyzan (2005) using an extended version of the Balassa-Samuelson model finds evidence that changes in oil prices had a significant effect on the real exchange rate during 1996 to 2003 and that the Balassa- Samuelson working through productivity changes may be present though its economic significance may not be large. Cashin et al (2004) carried out a study on over 50 commodities exporting developing countries and he finds along-run relationship between exchange rate and the exported commodity's price in one third of their sample. In a recent study, Ozsoz and Akinkunmi (2011) also demonstrated the positive effects of international oil prices on Nigeria's exchange rate.

Using monthly panel of G7 countries Chen and Chen (2007) investigate the long run relationship between real oil price and real exchange rates and they found that real oil prices is a dominant cause of real exchange rate movements. Olomola (2006) investigated the impact of oil price shocks on aggregate economic activity in Nigeria. Using quarterly data from 1970 to 2003. He discovered that contrary to previous empirical findings, oil price shocks do not affect output and inflation in Nigeria significantly. However oil price shocks were found to significantly influence the exchange rate.

In Bahrain Johansen co integration test is used to examine the co integrating relationship between the real GDP, real effect exchange rate and real oil price of a country. Real GDP of Bahrain is more elastic to changes in international oilprices than real exchange rate (Al – Zee, 2011).Research conducted on Vietnam from the period of 1995 to 2009 using the vector

autoregressive model (VAR) produce results that suggest that both oil prices and the real effective exchange rates have strong significant impact on economic activity.

Habib and Kalamova (2007) investigate the effect of oil price on the real exchange rate of three countries Norway, Saudi Arabia and Russia. In case of Russia a positive long run relationship was found between oil price and exchange rate and no impact of oil price on exchange rate was found for Norway and Saudi Arabia. Aliyu (2009) and Rickne (2009) believe that this is caused because of lack on strong institutions and total dependency on oil exports. Aliyu (2009) recommends larger divergence of the economy through the investment in top prolific sector to reduce the adverse effect of oil price shocks and the exchange rate volatility. Oil price has a strong influence on oil dependent countries and their currency is referred to as oil currency whereas for countries like Norway and Canada which are developed and have strong institutions there are weak influences of oil price on exchange rate and economic activities in this countries.

#### 4.0 Theoretical Framework and Methodology

The theoretical framework of this study is based on Generalized Autoregressive Conditional Heteroskedasticity modeled by Tim Bollerslev (1986) and Exponential General Autoregressive Conditional heteroskedastic modeled by Daniel Nelson (1991). The models are used to estimate the relationship between oil price changes and exchange rate. Bollerslev introduced the GARCH model by extending the work of Robert Engle (1982) framework and has been popular since the early 1990s. The daily nominal return on exchange rate is denoted as  $grex_t$ , while the daily nominal return on oil price is denoted as  $groil_t$

The daily returns are computed as follows:

$$grex_t = \log\left(\frac{er_t}{er_{t-1}}\right)$$

$$groil_t = \log\left(\frac{brent_t}{brent_{t-1}}\right)$$

$grex_t$  is an indicator for the daily returns on exchange rate, while  $er_t$  represents naira-dollar exchange rates for period's t and  $er_{t-1}$  is the lag of naira-dollar exchange rates. For thenominal oil returns,  $groil_t$ , represents the daily returns on oil price,  $brent_t$  is the daily spotprice for Brent crude oil for the periods t and  $brent_{t-1}$  is the lag of the daily spot price for Brent crude oil.

GARCH (1, 1) specification takes the form:

$$a + \zeta groil_t + \mu_t, \mu_t \sim N(0, \delta^2)$$

$$h_t = \alpha_0 + \alpha_1 \mu_{t-1}^2 + \beta h_{t-1}$$

The equation of the mean is a function of a constant, one regressor and an error term. The error term  $\mu_t$  is called white noise  $(0, \delta_t^2)$ . The variance equation for GARCH (1, 1) is written as a function of a constant term, the ARCH term which means autoregressive conditional

heteroskedasticity captures reports about volatility from the earlier period measured as the lag of squared residuals from the mean equation and the last forecast period. The coefficients  $\alpha_1$  and  $\beta$  are positive to make sure the conditional variance  $h_t$  is always positive (Roman, 2010). The non-negativity restrictions are considered necessary to guarantee that  $h_t > 0$  in all periods and the upper bound  $\alpha + \beta < 1$  is required in order to make the  $h_t$  stationary and consequently the unconditional variance finite (Soderlind, 2011). The condition  $\alpha + \beta < 1$  may not be met due to persistent instability of many financial time series but a unity sum of both  $\alpha_i$  and  $\beta_j$  leading to the integrated GARCH (IGARCH). Nevertheless even if a GARCH is not covariance stationary,

Nelson (1990), Bougerol and Picard (1992) and Lumsdaine (1991) and Wang (2003) observed that standard asymptotically based inference procedures are generally valid. An alternative GARCH equation, the (GARCH-M) GARCH-in-mean is also considered in this study, by incorporating the conditional variance in to the mean equation and it takes the following form.

$$g_{rex_t} = \alpha + \zeta g_{roil_t} + \lambda h_t + \mu_t$$

Higher order GARCH (q, p) can be estimated with the variance equation taking the form:

$$h_t = \alpha_0 + \sum_{i=1}^q \alpha_i \mu_{t-1}^2 + \sum_{i=1}^p \beta_i h_{t-i}$$

Nelson (1991) first brought up the Exponential GARCH or EGARCH model as an alternative to the GARCH model due to the perceived problems with standard GARCH (q, p) model. The EGARCH captures asymmetric responses of the time varying variance to shocks and ensures variance is positive. The representation of the EGARCH variance takes the form:

$$\ln(\delta_t^2) = \alpha_0 + \phi \ln(\sigma_{t-1}^2) + \gamma \frac{\mu_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \chi \left[ \frac{\mu_{t-1}}{\sqrt{\delta_{t-1}^2}} - \sqrt{2/\pi} \right]$$

The parameters to be estimated are  $\alpha_0$ ,  $\phi$ ,  $\gamma$  and  $\chi$ . The left hand side is the log of the conditional variance; hence the leverage effect is exponential as opposed to quadratic with the estimates of the conditional variance guaranteed to be positive. Also being written in terms of log make  $h_t > 0$  hold without any restrictions on parameters. According to Wang et al (2011), the EGARCH benefits from the non-negativity constraint which Nelson believed is too restrictive in linear GARCH model which requires all the explanatory variables in a GARCH to be positive.  $\alpha_0$  represents the mean of the volatility equation,  $\phi$  denotes the size effects which shows how much volatility increases notwithstanding the shock direction. The estimate of  $\chi$  is used to evaluate the different perceptions of shocks. The absolute value of  $\chi < 1$  ensures stationary and periodicity for EGARCH (P, Q).

$\gamma$  is the asymmetric response parameter, it is the sign effect which determines whether positive shocks gives rise to higher volatility than negative shock or vice versa. According to

Soderlind (2011), the EGARCH (exponential GARCH) is an asymmetric model; the  $|\mu_{t-1}|$  term is symmetric which means that both positive and negative values of  $\mu_{t-1}$  influence volatility in the same way. The linear term in  $\mu_{t-1}$  modifies this to make the effect asymmetric. If  $\gamma < 0$ , then the volatility increases more in response to a negative  $\mu_{t-1}$  than to a positive  $\mu_{t-1}$ .

#### 4.1 Model Specification and data sources

In line with the GARCH model theory which makes the exchange rate dependent on the oil price. A model was constructed to include: FOREX supply and demand for external reserves.

$$Vol\_EXR = f(oilp, er, int)$$

$$Vol\_EXR = \beta_0 oilp^{\beta_1} er^{\beta_2} int^{\beta_3}$$

$$\log Vol\_EXR_t = \beta_0 + \beta_1 \log oilp_t + \beta_2 \log er_t + \beta_3 \log int_t + \mu_t$$

Where:  $\beta_0$ : constant term,  $\beta_1 - \beta_3$ : elasticity coefficients and  $\mu$ : stochastic disturbance term

#### Data Sources and Descriptions

VARIABLE	DESCRIPTION/ MEASUREMENTS	DATA SOURCES
OIL PRICE (oilp)	The price of crude oil is stated in US dollars. Oil price is the price at which oil is sold per barrel each day in the international oil market. It is measured in US dollars	BP statistical review of energy 2012
EXTERNAL RESERVES (er)	This is the amount of revenue saved by country from trading with other nations. It is measured in US dollars millions	CBN statistical bulletin 2011
Interest rate (int)	It is the charge for borrowing money, usually measured as the percentage ratio between the sum payable to the lender and the amount borrowed, at an annual rate. The amount of money contractually promised at certain specified future dates as a proportion of the principal borrowed.	CBN statistical bulletin 2011
EXCHANGE RATE (vol_exr)	It is the price of a country currency expressed in terms of one unit of another country's currency. It is measured as the exchange rate of the naira to the dollar.	Figures for exchange rate derived from CBN statistical bulletin while volatility figures are conditional variances generated using E-Views 5.0

#### 4.2 Research Methodology

The econometric technique used is the Johansen maximum likelihood estimation method and also to test for co integration the vector error correction model (VECM) is employed. The Eviews 5.1 software package would be used for estimation. The choice of this co integration is as a result of the fact that i. most time series data are not stationary that is they do not have

a constant mean, a constant variance and a constant auto variance for every successive lag, so the use of the OLS method of estimation would only yield unauthentic results. ii. co integration view is a convenient approach for the estimation of long run parameters with unit root. iii. The co integration approach provides a direct test of the economic theory and enables utilization of the estimated long run parameters into the estimation of the short run disequilibrium relationships. iii. The traditional approach is criticized for ignoring the problems caused by the presence of unit roots variables in the data generating process. However both unit root and co integration have important implications for the specification and estimation of dynamic models

#### 4.2.1 The Test for Stationarity (Unit Root)

The unit root test is conducted before the co-integration method of analyses can be carried out; this is because it is necessary to test for the presence of a unit root in a variable. A unit root test tests whether time series variable is non-stationary using autoregressive model. A common test and valid for large samples is the Augmented dickey fuller (ADF) and Phillips Perron test. They are used to determine the order of integration of a variable. The test states that if a particular series say Y has to be differenced n times (number of times, 1, 2, 3... n) before it becomes stationary then Y is said to be integrated of order n (it is written as  $I(n)$ ). If the series is stationary at level it is said to be integrated to order 0 ( $I(0)$ ), that is there is no unit root. If a variable is differentiated once in order for it to be stationary it is said to be integrated to order 1 that is  $I(1)$ .

The test statistics of the estimated coefficient of  $Y_t$  is then used to test the null hypothesis that the series is non-stationary (has unit root). If the absolute value of the test statistics is higher than the absolute value of the critical T value (which could be at 1, 5, or 10 percent) then he series is said to be stationary, therefore we reject the null hypothesis, otherwise it has to be differentiated until is stationary.

#### 4.2.2 Johansen Test for Co-integration

Co-integration is basically based on the idea that there is a long run co movement between trended economic time series so that there is a common equilibrium relation which the time series have a tendency to revert to, therefore even if certain time series, they are non-stationary, a linear combination of them may exist that is stationary. A lot of economic series behave like  $I(1)$  processes that is they seem to drift all over the place, but another thing to notice is that they seem to drift in such a way that they do not drift away from each other. Formulating it statistically you will come up with a co integration model.

Johansen test named after Soren Johansen, is procedure, is a procedure for testing co integration of several  $I(1)$  time series. This test permits more than one co integrating relationships, so it's more applicable than the Engle-Granger test which is OLS based. There are two types of Johansen test, Trace and Maximal Eigen value which are used to test for co integration and they are also used to determine the number of co integrating vectors. Both tests do not always indicate the same number of co integrating vectors. The trace test is a joint test, the null hypothesis is that the number of co integrating vectors is less than or equal to r against a general alternative hypothesis that there are more than r. the Maximal Eigen

value test conducts separate test on each Eigen value. The null hypothesis is that  $r$  co integrating vectors present against the alternative that there are  $(r+1)$  present. If there are  $g$  variables in the system of equations, there can be a maximum of  $g-1$  co integrating vectors.

#### 4.2.3 The Vector Error Correction Model

This is basic VAR, with an error correction term incorporated into the model. The reason for the error correction term is the same as with the standard error correction model, it measures any movements away from the long run equilibrium and measures the speed of adjustment of the short run dynamics to the long run equilibrium time path. The coefficient is expected to be negatively signed. The vector error correction model would be used to analyze the short run relationship between the world crude oil price and the Nigerian exchange rate.

#### 4.2.4 Garch (1,1) Model

The exchange rate volatility aspect of the model is estimated using the GARCH (1,1) model of estimation. It is believed that the GARCH model can generate good estimates of exchange rate volatility (Egwaikhide and Udoh, 2008)

The GARCH model was developed independently by Bollerslev (1986) and Taylor (1986). It is used by several professionals in several areas including, trading, investing, hedging and dealing. The process for GARCH model involves three steps: estimate the best fitting autoregressive model, compute autocorrelations of the error term and lastly test for significance. GARCH method presumably captures risk in each period more sensibly than simply rolling standard deviations which gives equal weights to correlated shocks and single outliers. Development of the model is premised on two different specifications. There is one for the conditional mean and another for the conditional variance (Onwusor, 2007).

The GARCH model allows the conditional variance to be dependent upon pervious own lags, so that the conditional variance in the case is:

$$\delta_t^2 = \alpha_0 + \alpha_1\mu_{t-1}^2 + \beta\delta_{t-1}^2$$

$\delta_t^2$  is known as the conditional variance. Since it is one period ahead estimate for the variance calculated is based on any past information thought relevant.

Adapting GARCH model used by Papertrou to model oil price volatility, the mean equation of the GARCH model is specified as:

$$\Delta lex_t = \alpha_0 + \alpha_1\Delta lex_{t-1} + \mu_t$$

In the mean equation,  $\Delta LEX$  represents the rate of increase in the exchange rate expressed as the difference of the logarithm of the exchange rates; and  $\mu_t$  is a random error that is Gaussian in nature implying that the error term is dependent upon itself.

The exchange rate that is used is sourced from the CBN website and the GARCH model is used to generate the conditional variance series that is subsequently used as the exchange rate volatility time series data from 1980 to 2011

## 5.0 Econometrics Analysis

### 5.1 Test for Unit Root

Unit root test is carried out to determine if the variables are stationary and if not, to determine their order of integration (i.e. number of times they are to be differenced to achieve stationarity). In standard econometric analysis of the data used in research, a stationary test was carried out; this is due to the fact that most time series data are non-stationary. The Augmented Dickey Fuller test (ADF) test for unit roots and the Phillips Perron (PP) test were conducted for at the time series employed in the study. The Augmented Dickey Fuller (ADF) result and the Phillips Perron (PP) test show that LEXRV, LOILP, LER AND LINT are all integrated series of order I (1).

Augmented Dickey - Fuller and Phillips Perron test for unit root

Variable	Augumted Dickey fuller test (ADF)				Phillips Perron PP			
	Level	Order of Integration	First difference	Order of Integrati on	Level	OI	First Difference	OI
LEXRV	-1.062207	I(0)	-18.62853*	I(1)	-0.529109	I(0)	-16.39442*	I(1)
LOILP	-2.137543	I(0)	-6.058508*	I(1)	-2.137724	I(0)	-6.058478*	I(1)
LER	-2.207279	I(0)	-6.719037*	I(1)	-2.166444	I(0)	-7.124260*	I(1)
LINT	-2.048322	I(0)	-9.138885*	I(1)	-1.878074	I(0)	-9.863937*	I(1)

\* Variable stationary at 1%, 5% and 10% critical values.

\*\* Variables stationary at 5% and 10% critical values

\*\*\* Variables stationary at 10% critical values

The table above shows that all the variables are not stationary at level. This can be seen by comparing the observed values (in absolute terms) of the Augmented Dickey fuller (ADF) test and Phillips Perron test statistics with the critical value (also in absolute terms) at 1%, 5% and 10% level of significance. As a result of this, the variables were differenced once and from the table above it can be seen that the variables are stationary at first difference, since all the variables are integrated of the same order.

Johansen Maximum Likelihood Test of Co-integration

The major aim of this test is to find out if a linear combination of the integrated variable is becomes stationary over the long-run, if it is, then it means co-integration exists among the variables, this further implies that there exist a long run relationship among the variables. The Johansen co integration test commenced with the test for the number of co integrating relations or rank using Johansen's maximum Eigen value and the trace test. The results are shown below:

Number of co-integrating equation $H_0$ :	Trace Statistic		Maximum Eigen value	
	Statistic	0.05 Critical value	Statistic	0.05 Critical value
None	79.88171	63.87610	40.88306	32.11832
<b>At most 1*</b>	<b>38.99865*</b>	<b>42.91525*</b>	<b>18.28741*</b>	<b>25.82321*</b>
At most 2	20.71124	25.87211	14.19844	19.38704
At most 3	6.512805	12.51798	6.512805	12.51798

\*Reject  $H_0$  for the co-integrating rank test (Trace and Maximum Eigen Value) Statistic

The hypotheses are stated below

$H_0$ : there is no co-integrating relationship among the integrated variables

$H_1$ : there is a co-integrating relationship among the integrated variables

The two tests produced the same result. The trace test rejected the null hypothesis ( $H_0$ ) that there is no co-integrating relationship between the variables and the test base on the maximum Eigen value also rejected the null hypothesis. They both show that there is one co-integrating equation at the 0.05 level of significance. Since the two tests are giving the same result, it shows that there is a co-integrating equation. The result of the co-integration test showed that LEXRV, LOILP, LER AND LINT have equilibrium condition which keeps them in proportion to each other in the long run. The exactly identifying estimates of the Johansen Maximum likelihood estimates showing the co-integrating coefficients normalized to LEXRV are shown below. They are very useful in understanding the long run relationships among co-integrating variables.

Normalized Co-integrating coefficients

Variables	LEXRV	LOILP	LER	LINT
Coefficients	1.000000	2.860249	-0.531970	-0.532029
Standard Error		(0.3.1751)	(0.29149)	(0.91854)
		9.0083	-1.70905	0.0012114

The model is in double logged form, the co-efficient estimates can be interpreted in terms of long run elasticity and the t-statistics is used to determine the statistical significance of each variable. Based on the rule of thumb, a variable is said to be statistically significant if the absolute value of its t-statistic is approximately 2 or above.

The major relationship of interest is that which exists between oil price and exchange rate volatility in Nigeria. From the table oil price is elastic in relation to exchange rate volatility, meaning that in the long run, a change in oil price will cause a more than proportionate change in exchange rate volatility and the t-statistic of LOILP shows that the co-efficient is statistically significant.

## 5.2 The vector error correction model

The ECM coefficient is known as the speed adjustment factor, it tells how fast the system adjusts to restore equilibrium. It captures the reconciliation of the variables over time from

the position of disequilibrium to the period of equilibrium. The result of the vector correction model (VECM) is shown on table 4.3.5 the basic criteria for analyzing VECM are:

1. The VECM must lie between 0 and 1
2. It must be negative for it to be meaningful

If it is positive there is no error correction and it diverges and the T-statistic must be significant i.e. it must be greater than 2.

VECM result

Variables	ECM(-1)	T-statistic
D(LEXRV)	-0.633566	-10.2559
D(LOILP)	-0.037631	-1.11319
D(LER)	-0.011029	-0.13882
D(LINT)	-0.012318	-0.60156

Source: Computed by author using E-views 5.

The speed of adjustment co-efficient for LEXRV is -0.633566. The VECM is correctly signed and in terms of magnitude it lies between 0 and 1. This significance supports co-integration and as it shows that there exists a long run steady equilibrium between exchange rate volatility and the explanatory variables. Precisely the error correction model in this equation means that about 63.35% of errors generated between each period are correlated in subsequent periods. This result is sizeable and also significant judging from the value of the T-statistic [-10.2559].

The study was carried out majorly to determine the effects of oil price on exchange rate volatility in Nigeria. The result obtained is in line with the expectation of the study. It showed that a proportionate change in oil price leads to a more than proportionate change in exchange rate volatility by 2.86. This indicates a change in international oil price will have a greater effect than expected on exchange rate volatility in Nigeria. In the long run the coefficient of elasticity of 2.8% implies that exchange rate volatility is elastic to changes in the oil price since the coefficient is greater than one. It is statistically significant based on the t-statistic.

Crude oil is the mainstay of Nigeria's economy. It affects all her economic activities and influences are macroeconomic variable including exchange rate. The result obtained showed that a proportionate change in external reserves leads to a less than proportionate change in exchange rate volatility. This is in line with the expectation of the study. This means that a change in external reserves for Nigeria will have less than the expected change in exchange rate volatility in Nigeria. In the long run the coefficient of elasticity of 0.53% implies that exchange rate volatility is inelastic to changes in the exchange rate volatility since the coefficient is less than one. Based on the rule of thumb that a variable is said to be statistically significant if the absolute value of the t-statistic is approximately 2 or above, that means a significant relationship exist between external reserves and exchange rate volatility.

According to Ketil (2004) a reasonable level of external reserves is sufficient to reduce a country's exchange rate volatility. Nigeria's external reserves increases when oil revenue increase and this eternal reserves can be used to reduce exchange rate volatility.

A proportionate change in oil price leads to a less than proportionate change in interest rate. This is not in line with the expectation of the study. This means that a change in Nigeria's interest rate will have a smaller effect than expected on exchange rate volatility. In the long run the coefficient of elasticity of 0.53% implies that exchange rate volatility is inelastic to changes in Nigeria's interest rate since the coefficient is less than one. This implies that a change in Nigeria's interest rate will not have a significant impact on exchange rate volatility in Nigeria and it is not statistically significant looking at the t-statistic.

When a country's interest rate is high, it attracts investment from abroad which increases its exchange rate but when inflation in the country is high like in Nigeria, it mitigates the influence of interest rate on exchange rate.

### Recommendation and Conclusion

This research study set to find out if oil price as a significant influence on exchange rate volatility in Nigeria over the periods 1970 -2010 by analyzing time series data. It also looks at other factors that can influence exchange rate in Nigeria like external reserves and interest rate. To achieve these objectives, a model was formulated based on GARCH model. In the model exchange rate volatility was the dependent variable and the independent variables were oil price, external reserves and interest rate. After the review of relevant literature and the necessary empirical analyses it was observed that a proportionate change in oil price will lead to a more than proportionate change in exchange rate volatility.

In the words of Jin (2008), Exchange rate volatility increases the risk and uncertainty of external transactions and predisposes a country to exchange rate related risks. For the purpose of this research work, the following strategies are suggested to reduce exchange rate volatility in Nigeria.

- i. Ketil (2004) research on the effect of external reserves on exchange rate volatility after enforcing controls for the endogeneity induced by the exchange rate regime that can affect both reserves and exchange rate showed that a high level of external reserves reduce exchange rate volatility. Therefore Nigeria government should take advantage of increases in the price of oil price by Nigeria external reserves and reduce exchange rate volatility.
- ii. Research carried out on exchange rate volatility by Adeoye and Atanda showed that there is presence and persistency of volatility shocks in the nominal and real exchange rates for naira vis-à-vis U.S dollar in Nigeria between 1986 and 2008. This implies that the conservative monetary management policies put in place for stabilizing the exchange rate of a unit U.S dollar to naira over the years has been ineffective. There is a need for FOREX management measures particularly in terms of meeting the high demand for foreign currency which characterized and order the performance and trade balance and overall economic performance in Nigeria. There is also the need for sound monetary policy to attain stability in the exchange rate.
- iii. According to the Brahmabhatt et al (2010), resources that a gift by God to a country prices and revenues are a lot unpredictable because of the small diminutive supply

elasticity of natural resource yield. Assuming government expenditure is closely aligned to revenue from natural resource, the revenue will become more unpredictable. Expenditure instability, will in turn cause instability in the real exchange rate. A bulky body of empirical work records the terrible effect of the impact of economic volatility on investment and growth. Therefore Nigeria government should look for new ways to diversify the economy from dependence on oil and explore other sectors like manufacturing sector and agricultural sector to reduce volatility in the economy and the overall effect on it.

- iv. Lastly, higher revenue gotten from increases in oil prices should be invested different areas of the economy the economy as the exchange rate of a country is affected by state of the economy.

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