Oil Price Volatility and Macroeconomic Performance in Selected African Countries

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Abstract

Policymakers are concerned with large price movements in the crude oil market, as this has possible effect on the macroeconomy. This paper examined oil price volatility and its effect on macroeconomic performance of eight African countries for the period 1980-2012 based on data availability and categorized them into oil exporting and importing countries, applying recently developed panel cointegration methods. The results showed that oil price volatility impeded on the macroeconomic variables of oil importing countries of Africa and facilitated the macroeconomic performance of oil exporting countries of Africa. The study recommended that individual economy be protected against the adverse effects of such volatility through diversification of the sources of revenue generation against external shocks.

Keywords: Oil price volatility, macroeconomic performance, fully modified OLS, dynamic OLS

JEL Classification: E6, E00, Q4, Q430

Introduction

Experts opined that energy plays an essential part in the world economy (Afia, 2008). In spite of considerable inclination to alternative renewable sources of energy like wind, water, nuclear and solar power, the role of crude oil in macroeconomic movements especially as regards to its price has not waned. Oil prices have been volatile since the large price increases of the 1970s and 1980s. More so, the wide price fluctuations in 2007, when daily spot prices for market crudes nearly doubled between January and November, and fluctuations by more than US$20 a barrel in early 2008, reinforced the idea that oil prices are volatile (Latife, 2011). Oil is important in every economy, as it is a major energy source. When its prices are high and volatile, government may be compelled to adapt and regulate her economy so that the unexpected change in price may not have direct diverse effect on their economies.

The greater the amount of oil a country consumes relative to its current GDP, the larger will be the consequences throughout the economy (Afia, 2008). The fluctuations in oil price, however, has effect on both the net exporting and importing nations of crude oil and its products. Experts believe that higher oil import costs affect the demand for other goods by limiting the revenue available for such venture. On the other hand, volatility of oil prices could slow down development of trade and export (Afia, 2008).

Oil price volatility may have macroeconomic consequences in both oil exporting and importing countries. In the former group, oil is the major source of revenue, while in the latter, it is a major input for production or manufacturing system. Due to this mutual strategic importance, oil price volatility poses a threat to the macroeconomy of both importing and exporting countries (Dehn, 2001). Fluctuations in prices of oil are hardly predictable. This fact led many researchers to critically investigate the effects of oil price changes on economic activities, identifying the mechanisms through which these effects transmit into concerned economy and proposing effective monetary and fiscal policies to prevent negative impacts of such shocks (Hamilton, 1983, 1996; Bernanke et al., 1997; Bernanke, 2004; Devlin and Lewin, 2004).

The magnitude of the direct effect of a given price increase depends on the share of the oil revenue/cost of import of oil in the national income, the degree of dependence on imported oil and the ability of end-users to reduce their consumption, that is, switch from oil to other sources of energy. In net oil-importing countries, higher oil prices lead to inflation, which inadvertently increase input costs, reduce non-oil demand and bring about low investment. Budget deficit may also increase in the face of government's effort to manage an unexpected rise in oil price. This may be due to rigidities in government expenditure, that is, government trying to keep up with other expenses while incurring more cost managing oil demand. When an oil importing nation is faced with increasing oil price, interest rate and exchange rate are impacted.

The level of impact that oil price volatility has on a nation's economy is also dependent on the vulnerability of the structure of that economy. Both oil-importing and exporting countries in Africa are vulnerable to oil price shocks, considering the fragile nature of their economies and their heavy dependence on crude oil, either as a revenue determiner or an industrial input. When oil price rises, government of oil exporting nations have more money to spend, and vice-versa (Kilian, 2009). Also, when the country's terms of trade are favourable, oil-dependent government's spending can be easily financed through oil revenue. Although, this revenue can be used to finance developmental projects to increase social welfare (Anashasy et al., 2005).

When oil prices fall and the government is not able to reduce its spending immediately and proportionately, the country incurs huge deficits. The fiscal imbalances followed by an oil price decrease can be devastating if the country is highly dependent on oil revenues, as is the case in most oil exporting countries like Nigeria, Algeria and Angola, to mention a few. Several incomplete projects and huge debts are inherited at such periods. After some harsh experiences, isolating the real sectors of the economy from oil price volatility is accepted as one of the most important roles of government (Afia, 2008).

A plethora of literature have studied the role and impact of oil price variation on macroeconomic indicators and have confirmed that oil price is significant to macroeconomic performance; but most of these studies focussed on oil price shocks, using impulse response functions from the variance autoregressive (VAR) approach. The current study, however, analysed oil price volatility through the Generalized Autoregressive Conditional Heteroschedasticity (GARCH) approach for measuring volatility instead of a shock. Also, an analysis of oil price variance from the perspective of its volatility and the attendant effects on macroeconomic performance is crucial for both oil importing and oil exporting countries, especially in Africa, struggling to come out of poor macroeconomic performances. To the best of our knowledge, there is still a dearth of information with regard to single studies that compared the effects on both oil-importing and exporting countries. The question on the effect of such volatility and how soon the region will be salvaged from poor macroeconomic performances remains unanswered. Thus, this study becomes imperative, since continuous involvement in international trade is a necessity for growth. Consequently, the study empirically examined the effects of oil price volatility on macroeconomic performance in selected African oil exporting and importing countries based on data availability. It also addressed possible government responses in the case of oil price volatility.

Literature Review

There recently exists a mass of academic literature focusing on the economic properties of oil, its impact on the aggregate world economy and, specifically, on economies of different types (such as net exporters or net importers of oil, emerging or developed economies, etc). Some studies considered the impact of oil on particular economic variables, i.e. estimated oil price pass-through into, say, exchange rate, inflation or unemployment; others estimated the system of equations, via appropriate econometric techniques, to account for the interrelationship between the included variables as well as external (exogenous) ones and did innovation accounting, i.e. computed impulse responses to oil price shocks, evaluated their significance, determined the magnitude, speed of convergence to the long-run value, as measured by the time it took for the reaction to disappear. Despite the numerous research in this line (McGuirk, 1983; Krugman1983a, 1983b; Golub, 1983 and Rogoff, 1991, Bekhet and Yusop, 2009; Korhonen and Mehrotra, 2009), there exists some sort of imprecision on the actual effects oil price volatility has on macroeconomic performance of both oil importing and exporting countries.

Different sources of real shocks have been investigated in Zhou (1995). Among many sources of real disturbances, such as oil prices, fiscal policy, and productivity shocks, it has been shown that oil price fluctuations play a major role in explaining real exchange rate movements. Moreover, Chaudhuri and Daniel (1998) investigated 16 OECD countries and found that the non-stationary behaviour of US dollar's real exchange rates is due to the non-stationary behaviour of real oil prices. Similar results were obtained by Amano and Norden (1998). By using data on real effective exchange rates for Germany, Japan, and the US, they found that real oil price is the most important factor determining real exchange rates in the long-run.

Bernanke et al. (1997) studied the role of monetary policy as the central issue, rather than a factor, contributing to discontinuity in the oil price-GDP relationship. They had evidence to show that if the Federal Reserve had maintained the fund rates at the pre-shock level, most of the GDP response to oil price over the 1973, 1979-80, and 1990 episodes would have been avoided. This suggests that most, if not all, of the reduction in GDP during the recessions following those episodes was attributable to monetary policy rather than oil price shocks themselves. They, however, stated that, that does not indicate that oil prices do not have impact on it.

Hamilton and Herrera (2001) re-examined Bernanke et al. (1997) and arrived at a completely opposite conclusion about the relative contributions of monetary policy and oil price shocks to the recessions following the 1973, 1979-80, and 1990 oil price shocks. Their analysis of the impulse response functions showed that the potential of monetary policy to avert the contractionary consequences of an oil price shock is not as great as suggested by Bernanke et al. Rather, oil shocks appear to have greater effect on the economy than suggested by their VAR approach. Hamilton and Herrera (2001) were not persuaded of the feasibility of implementing the monetary policy needed to offset even small shocks.

Backus and Crucini (2000) analysed the effect of terms of trade and volatility of oil price on the US economy and concluded that heightened terms of trade volatility is significantly related to increased oil price volatility, as opposed to fluctuations in nominal or real exchange rates that are both insignificant with respect to the terms of trade volatility.

In a study on the impact of oil price increase on the global economy, IMF (2000) found that the differential impact of an oil price increase of US$5 per barrel is greater for developed countries than for developing countries as a group, with differences in terms of the relative size of oil importing to exporting countries accounting for much of the disparity. Oil price shocks, on the other hand, were precisely shown to lower aggregate demand by redistributing income between net oil importers and exporters. The study further indicated that differences in oil intensity levels in domestic production, exports and imports, and degree of openness also accounted for some of the observed discrepancy. Additional results indicated that oil price change is positively correlated with economic growth in oil producing countries, while estimates of the first round impact of higher oil prices on GDP growth for some were found to be mixed.

Rautava (2004) analysed the effect of oil price changes on growth captured by real GDP and exchange rate in Russia. He submitted that oil price change has a long-run positive relationship with GDP; and that a 10% permanent increase (decrease) in international price of oil is associated with a 2.2% growth (decline) in the level of Russian GDP.

Yousefi and Wirjanto (2004) adopted a novel empirical approach to the crude oil price formation for the purpose of understanding the price reactions of OPEC member countries to changes in the exchange rates of US dollar against other major currencies and prices of other members. The results were broadly consistent with the view of literature on the absence of a unified OPEC-determined price in the international crude market. In addition, the results highlighted a cross-regional dimension of the crude oil market.

Using multivariate VAR analysis in a study involving major industrialised OECD countries, Jimenez-Rodriguez and Sanchez (2005) found that the response of real GDP to oil price shocks differ between net oil importers and exporters, with the exception of United Kingdom (net exporter) and Japan (net importer). Also, their asymmetric (non-linear) specification showed that oil price declines are significant only in few countries, while shocks to oil price, together with monetary shocks, were found to be the largest source of volatility in real output aside itself. The authors re-specified earlier models and employed standard vector autoregressive methods for linear and non-linear models. Their results indicated that non-linear impact of oil prices on real GDP is positively significant, especially as oil price increases influence GDP growth substantially than that of oil price declines, with the latter being statistically insignificant in most cases.

Chen and Chen (2007) investigated the long-run relationship between real oil prices and real exchange rates by using a monthly panel of G7 countries and using the likelihood-based cointegration test proposed by Larsson (2001). They found that real oil prices may be the dominant source of real exchange rate movements and that there is a link between real oil prices and real exchange rates. They then examined the ability of real oil prices to forecast future real exchange returns and found that panel predictive regression estimates suggested that real oil prices have significant forecasting power.

The VAR model analysis by Blanchard and Gali (2007) found that the relationship between oil price increase and GDP in 6 countries (US, UK, Germany, France, Italy and Japan) changed from negative to positive from the 2000s' shocks, in comparison to shocks of the 1970s and 1980s, in addition to minimal impacts on GDP, unemployment, wage and CPI for the period. Lardic and Mignon (2006) studied 12 European countries for the period 1970-2003 and found asymmetric relationship between oil price and economic activities; implying that rising oil prices retard aggregate economic activity more than falling oil prices.

Korhonen and Mehrotra (2009) focused on four energy producers and addressed the issue of oil price shocks on real exchange rate, output and inflation, using SVAR (Structural Vector Autoregressive model). Theoretical explanation of the empirical model is provided by a dynamic open economy. The Mundell-Fleming-Dornbusch model augmented with an oil price variable. Just as Rautava (2004) concluded, they found that oil price shocks does not account for a large share of movement in the real exchange rate.

In and across Africa, Aliyu (2009) investigated oil price shocks effect on the macroeconomic performance of Nigeria between 1980 and 2007 via VAR model, using different asymmetric transformations for oil price variable, among which were Hamilton's (1996) NOPI4 and Mork's (1989) specification. The latter survives a number of post-estimation tests, such as Wald and block endogeneity (granger causality), which support the significance of oil price coefficients in the model. Moreover, the Nigerian case is of particular interest as, on its example, one may observe how the asymmetry effect is reflected in an oil-exporting economy. The study found more significant positive effect of oil price increase, than adverse effect of oil price decrease, on real GDP. Moreover, Akpan (2009), using VAR model analysis, found a positively significant asymmetric effect of oil price shocks on real government expenditure in Nigeria, while such effect on industrial output growth was found to be marginal with observed significant appreciation of real exchange rate.

It is noteworthy that these findings reinforced those of earlier studies (Olomola and Adejumo, 2006; Ayadi, 2005) on Nigeria. Similarly, Aliyu (2009) used a non-linear approach and found evidence of both linear and non-linear effects of oil price shocks on real GDP in Nigeria. Precisely, the study found that asymmetric oil price increases in the non-linear models have larger positive impacts on real GDP growth than in other specifications. The study, which focused on the effects of oil price shock and real exchange rate volatility on real economic growth in Nigeria, found a unidirectional causality running from oil prices to real GDP and bidirectional causality from real exchange rate to real GDP and vice versa. It further indicated that oil price shock and appreciation in the level of exchange rate exert positive impact on real economic growth in Nigeria.

Farzanegan and Markwardt (2009) found a strong positive relationship between oil price changes and industrial output growth and real effective exchange rate for the Iranian economy. However, Jbir and Zouari-Ghorbel (2009) found that no direct impact of oil price shock on the economic activity in both linear and non-linear specifications in Tunisia; but that oil prices affect economic activity indirectly and that oil price shock was mostly transmitted via government's spending.

Moreover, while using vector autoregressive (VAR) methodology, Lorde et al. (2009) found that unanticipated shock to oil price volatility brought about random swings in the macroeconomy of Trinidad and Tobago. However, only government revenue and the price level exhibited significant responses, while magnitude of oil price volatility responses tended to yield smaller macroeconomic impacts. Also, granger-causality tests indicated causality from oil prices to output and oil prices to government revenue. Bekhet and Yusop (2009) also found evidence of a stable long-run relationship and substantial short-run interaction between oil price and employment, economic growth and growth rate of energy consumption in Malaysia; the relationship between oil price and employment was positive.

The literature above showed that most of the studies in Africa focused on oil price shocks using the VAR approach, which is at variance with the issue of volatility, and an indication of unanticipated fluctuations. Also, there is dearth of data on Africa with regard to analysis on oil importing and exporting countries' macroeconomic responses to oil price volatility.

Methodology

The data used were extracted from the World Bank (2012) dataset on World Development Indicators (WDI) CD-ROM for 8 African countries (consisting of 4 importing and 4 exporting countries) for the period 1980-2012. The countries and study period were selected based on data availability. Theoretically and empirically, a number of factors have been identified in the literature as macroeconomic responses to oil price volatility. However, these are categorized into different macroeconomic variables, ranging from inflation and economic growth to exchange rate.

GARCH model for measuring oil price volatility

The oil price volatility variable was generated using a GARCH model. Formally, the GARCH model was expressed as:

$$Y(t) = x(t) + e(t)\text{.........}(1)$$

$$e(t)\varphi t - 1 \sim N\left[0, \delta 2(t)\right]\text{.........}(2)$$

$$\sigma^2(t) = \alpha_0 + \sum_{i=1}^{p} \alpha_i e^2(t-i) + \sum_{j=1}^{q} \beta_j \sigma^2(t-j)\text{.........}(3)$$

Where the conditional information set at time *t*-1 is denoted by φt-1. The variance of the ARCH process exists when Σα<1 and is given by *(Y(t))* = α0/(1− Σαi). In this study *Y*(*t*) is equal to the change in *log* of either oil prices/inflation. *X*(*t*) is a *1*x *k* vector of lagged endogenous variables included in the information set. *P* is a *k*x*1* vector of unknown parameters. *P* and *q* are the order of the process.

Equation 3 is the variance equation, which contains three components: a constant, last period volatility (the ARCH term) and last period variance (the GARCH term). The autoregressive root which governs the persistence of volatility shocks is the sum of α and β. If the sum of α and β is very close to unity, then the shocks die out rather slowly. The existence of volatility is based on the above volatility modelling process. Equation 3 is used to generate the variance values of oil prices to capture volatility.

Empirical model

Following Hamilton and Herrera (2001), Chen and Chen (2007), and Ayadi et al. (2000), the follow is the model on the impact of oil price volatility on macroeconomic performance in Africa:

$$Marc = f(oilp, gdppc, m2, gfcf, exr, \inf, enrl)\text{.........}(4)$$

$$\inf = f(oilp, gdp, m2, exr)\text{.........}(4a)$$

$$gdp = f(oilp, gfcf, enrl, m2)\text{.........}(4b)$$

$$exr = f(oilp, gdp, \inf, m2)\text{.........}(4c)$$

Putting the above functional form in a fixed effect panel model gives:

$$Marc_{it} = \alpha_i + \psi_1 oilp_{it} + \psi_2 gdppc_{it} + \psi_3 m2_{it} + \psi_4 gfcf_{it} + \psi_5 exr_{it} + \psi_6 enrl_{it} + \psi_7 \inf_{it} + \varepsilon_{it}\text{.........}(5)$$

Where the dependent variable, MARC is macroeconomic response captured by economic growth, inflation and exchange rate. *Oilp* is the oil price volatility generated by the GARCH model. Real GDP per capita is used as proxy for economic growth. M2 is ratio of money supply to GDP, GFCF is the gross fixed capital formation, INF is inflation, EXR is exchange rate and ENRL is used to capture school enrolment rate.

Method of analysis

The study employed the panel data cointegration technique. For panel framework, several estimators have been proposed in the presence of cointegration: OLS, fully modified OLS (FMOLS), dynamic OLS (DOLS) and the pooled mean group (PMG) (Bangake and Eggoh, 2011). This study employed both the within-dimension and between-dimension panel FMOLS and DOLS techniques. The estimators correct the standard pooled OLS for serial correlation and endogeneity of regressors that are normally present in a long-run relationship. When applying cointegration tests to long-run hypotheses in aggregate panel data, a primary concern is to construct the estimators in a way that does not constrain the transitional dynamics to be similar among different countries in the panel. Thus, this study pooled only the information concerning the long-run hypothesis of interest, and allowed the short-run dynamics to be potentially heterogeneous. This was a central theme for the panel fully modified OLS tests that were developed by Pedroni (1996). Consider the regression:

$$Marc_{it} = \alpha_i + \beta_i x_{it} + \mu_{it} \qquad (6)$$

Where

$Marc_{it}$ is as defined;

x_{it} is the vector of explanatory variables as previously defined

$Marc_{it}$ and x_{it} are cointegrated with slopes β_i, which may or may not be homogeneous across i;

Let $\xi_{it} = (\mu_{it,} \Delta x_{it})$ be a stationary vector consisting of the estimated residuals from the cointegrating regression and the differences in x and let $\Omega_i = \lim T \to \infty E\left[T^{-1}(\sum_{t=1}^{T} \xi_{it})(\sum_{t=1}^{T} \xi_{it}^{'})\right]$ be the long-run covariance matrix for this vector process. This can be decomposed as $\Omega_i = \Omega_i{}' + \Gamma_i + \Gamma_i{}'$ where: Ω_i^0 is the contemporaneous covariance and Γ_i is a weighted sum of auto-covariance.

Based on Pedroni (2004), the expression for the between-dimension group mean panel FMOLS estimator was given as:

$$\hat{\beta}^*_{GFM} = N^{-1}\sum_{i=1}^{N}\left(\sum_{i=1}^{N}(x_{it} - \bar{x}_i)^2\right)^{-1} * \left(\sum_{i=1}^{N}(x_{it} - \bar{x}_i)Marc^*_{itit} - T\hat{y}_i\right) \qquad (7)$$

Where:

$$Marc^*_{it} = \left(Marc_{it} - Marc_i\right) - \frac{\hat{\Omega}_{21i}}{\hat{\Omega}_{22i}}\Delta x_{it,}$$

$$\hat{y} = \hat{\Gamma}_{21i} + \hat{\Omega}^{0}_{21i} - \frac{\hat{\Omega}_{21i}}{\hat{\Omega}_{22i}}\left(\hat{\Gamma}_{22i} + \hat{\Omega}^{0}_{22i}\right)$$

The between-dimension estimator was constructed as:

$$\hat{\beta}^{*}_{GFM} = N^{-1}\sum_{i=1}^{N}\hat{\beta}^{*}_{FM_i}$$

Where $\hat{\beta}^{*}_{FM_i}$ is the conventional FMOLS estimator applied to the *ith* member of the panel.

The associated t-statistics for the between dimension was obtained as:

$$t_{\beta^{*}_{GFM}} = N^{-1/2}\sum_{t=1}^{N} t_{\hat{\beta}^{*}_{FMi}}$$

Where: $t_{\hat{\beta}^{*}_{FMi}} = \left(\hat{\beta}^{*}_{FM,i} - \beta_0\right)\left(\hat{\Omega}^{-1}_{11i}\sum_{t=1}^{T}(x_{it} - \bar{x}_i)^2\right)^{1/2}$

To construct the between-dimension, group mean panel DOLS estimator, the study first augmented the cointegrating regression with lead and lagged differences of the regressor to control for the endogenous feedback effect, which plays similar role in the FMOLS procedure:

$$Marc_{it} = \alpha_i + \beta_i x_{it} + \sum_{k=-k_i}^{k_i} \gamma_{it}\Delta x_{it-k} + \mu_{it} \quad \text{.........(8)}$$

From the equation 8, the group-mean panel DOLS estimator was given as:

$$\hat{\beta}^{*}_{GD} = \left[N^{-1}\sum_{i=1}^{N}\left(\sum_{t=1}^{T} z_{it} z'_{it}\right)^{-1}\left(\sum_{t=1}^{T} z_{it} Marc_{it}\right)\right]_1$$

Where

z_{it} is the 2(k+1)*1 vector of regressors $z_{it} = (x_{it} - \bar{x}_i), \Delta x_{it-k,...,} \Delta x_{it+k}$

$Marc_{it} = Marc_{it} - \bar{Marc}_i$ and subscript 1 outside the brackets indicated that only the first element of the vector was taken to obtain the pooled slope coefficient.

The between-dimension estimator was constructed as:

$$\beta^*_{GD} = N^{-1}\sum_{i=1}^{N}\beta^*{}_{D,i}$$

Where, $\beta^*{}_{D,i}$ is the conventional DOLS estimator applied to the *ith* member of the panel. Similarly, if $\delta_i^2 = \lim T \to \infty E\left[T^{-1}\left(\sum_{t=1}^{T}\hat{\mu}^*{}_{it}\right)^2\right]$ is denoted to be the long-run variance of the residuals from DOLS, the associated t-statistics for the between-dimension estimator was obtained as:

$$t_{\hat{\beta}^*_{GD}} = N^{-1/2}\sum_{i=1}^{N} t_{\hat{\beta}^*_{D,i}}$$

Where

$$t_{\hat{\beta}^*_{D,i}} = \left(\hat{\beta}^*_{D,i} - \beta_0\right)\left(\hat{\delta}_i^{-2}\sum_{t=1}^{T}\left(x_{it} - \bar{x}_i\right)^2\right)^{1/2}.$$

The panel unit root test

To verify that all the variables were integrated to the same order, the study used first-generation tests of panel unit roots of Im et al. (2003) and Maddala and Wu (1999) and a second-generation test of the panel unit root of Pesaran (2005). These tests are less restrictive and more powerful than the tests developed by Levin and Lin (1993) and Levin et al. (2002), which do not allow for heterogeneity in the autoregressive coefficient. The tests proposed by IPS allow for the solving of Levin and Lin's serial correlation problem by assuming heterogeneity between units in a dynamic panel framework. The basic equation for the panel unit root tests for IPS is:

$$\Delta y_{i,t} = \alpha_i + p_i y_{i,t-1} + \sum_{j=1}^{p}\phi_{ij}\Delta y_{i,t-j} + \varepsilon_{i,j}; i = 1,2,.....N; t = 1,2,.....T \qquad (9)$$

Where

yi, *t* stands for each variable under consideration in the model,

αi is the individual fixed effect,

p is selected to make the residuals uncorrelated over time. The null hypothesis is that *ρi*=0 for all *I* versus the alternative hypothesis that *ρi*=0 for some *i=1,...,N1* and *ρi*=0 for *i=N1*+1,...,*N*.

The IPS statistic is based on averaging individual Augmented Dickey-Fuller (ADF) statistics and can be written as follows:

$$t = \frac{i}{n}\sum_{i=1}^{N} t_{IT,} \qquad (10)$$

Where

t_{IT} is the ADF t-statistic for country *i* based on the country specific ADF regression, as in Eq. 10

IPS shows that under the null hypothesis of non-stationary in panel data framework, the *t* statistic follows the standard normal distribution asymptotically. The standardised statistic t_{IPS} is expressed as:

$$t_{IPS} = \frac{\sqrt{n}\left(t - \frac{1}{N}\sum_{i=1}^{N} E\left|t_{iP}\right|\rho_i = 0\right|\right)}{\sqrt{\frac{1}{N\sum_{i=1}^{N} Var\left|t_{iP}\right|\rho_i = 0\right|}}} \qquad (11)$$

Panel cointegration test

After the order of stationarity has been defined, the study applied Pedroni's (1999) cointegration test methodology. Indeed, like the IPS and MW panel unit root, the panel cointegration tests proposed by Pedroni take in account heterogeneity by using specific parameters that are allowed to vary across individual members of the sample. Taking into account such heterogeneity constitutes an advantage because it is unrealistic to assume that the vectors of cointegration are identical among individuals on the panel. The implementation of Pedroni's cointegration test requires estimating first the following long-run relationship:

$$MARC_{it} = \alpha_i + \delta_{it} + \beta_i Z_{it} + \varepsilon_{it,} \qquad (12)$$

Where

Z represents all the explanatory variables for *i=1, ..., N; t=1, ... T*; where *N* refers to the number of individual members in the panel and *T* refers to the number of observations over time. The structure of estimated residuals is:

$$\hat{\varepsilon}_{it} = \hat{\rho}_i \hat{\varepsilon}_{it-1} + \hat{u}_{it} \qquad (13)$$

Pedroni (1999) proposed seven different statistics to test panel data cointegration. Out of this number, four are based on pooling (what is referred to as the 'within' dimension), while the last three are based on the 'between' dimension.

Both kinds of tests focus on the null hypothesis of no cointegration. However, the distinction comes from the specification of the alternative hypothesis. For tests based on 'within', the alternative hypothesis was $\rho i=\rho b=1$ for all i, while for the last three test statistics that were based on the 'between' dimension, the alternative hypothesis was $\rho ib1$ for all i. The finite sample distribution for the seven statistics has been tabulated by Pedroni through Monte Carlo simulations. The calculated statistic tests must be smaller than the tabulated critical value to reject the null hypothesis of the absence of cointegration.

Empirical Analysis

Panel unit root tests result

Tables 1 and 2 report the outcome for both the homogenous panel unit root process tests (Levin et al. 2002 and Breitung, 2000) and heterogeneous panel unit root process tests (Im et al., 2003) and the ADF-Fisher results. It can be deduced from the table that the null hypothesis of the unit roots for the panel data for the variables could not be rejected when the variables are taken in level.

Table 1: Panel unit root test results for oil importing countries

	Homogeneous Unit Root Process				*Heterogeneous Unit Root Process*			
	level		*1st diff*		*level*		*1st diff*	
Variables	*LLC*	*Breitung*	*LLC*	*Breitung*	*IPS*	*ADF-Fisher*	*IPS*	*ADF-Fisher*
OILP	-0.45	2.43	-4.87***	-4.23***	-5.54	8.23	-19.2***	252.5***
GDP	0.83	2.43	-5.23***	-2.45***	-2.44	-4.22	-5.67***	67.87***
EXR	0.62	-3.11	-4.23***	-4.33***	-1.23	9.24	-4.27***	32.47***
INF	0.76	3.11	-6.12***	-3.56***	2.34	-8.56	-3.83***	31.55***
GFCF	-0.87	-3.23	-8.11***	-4.29***	2.56	9.92	-7.64***	59.25***
ENRL	-2.21	-4.34	-7.56***	-6.89***	-0.63	-7.98	-5.58***	45.68***
M2	0.67	0.91	-6.12***	-5.19***	0.34	6.34	-3.67***	28.10***

Note: *** indicates significant at 1%; IPS=Im, Pesaran and Shin; LLC=Levin, Lin and Chu

These results strongly indicate that the variables are non-stationary in level and stationary in first differences. This finding is supported by both the homogenous and heterogeneous panel unit root tests. However, this hypothesis was rejected when series are in first differences. Since the variables became stationary after first difference, the study proceeded to establish their long-run relationship (Table 2).

Table 2: Panel unit root test results for oil exporting countries

	Homogeneous Unit Root Process				*Heterogeneous Unit Root Process*			
	level		*1st diff*		*level*		*1st diff*	
Variables	*LLC*	*Breitung*	*LLC*	*Breitung*	*IPS*	*ADF-Fisher*	*IPS*	*ADF-Fisher*
OILP	-0.27	1.45	-3.42***	-3.23***	-1.23	2.34	-18.3***	252.5***
GDP	-0.22	-0.61	-2.33***	-4.56***	-0.87	-9.87	-2.88***	23.01***
EXR	1.45	-2.86	-3.22***	-4.67***	0.52	-8.66	-5.38***	41.81***
INF	0.82	-0.91	-7.98***	-9.56***	2.41	-6.87	-8.02***	62.88***
GFCF	0.56	-0.32	-2.76***	-6.89***	-0.45	-9.71	-5.82***	43.94***
ENRL	-0.91	0.87	-4.78***	-5.87***	0.72	8.33	-4.67***	35.21***
M2	-1.24	0.98	-8.34***	-5.98***	0.91	9.88	-2.96***	22.54***

Note: *** indicates significant at 1%; IPS=Im, Pesaran and Shin; LLC=Levin, Lin and Chu

Panel cointegration test results

The data in Table 3 are the outcome of Pedroni's (1999) panel cointegration tests on the series that were between macroeconomic performance and the explanatory variables in the model. Four 'within dimension' and three 'between-group dimension' tests were used to check whether the panel data were cointegrated. The columns labelled within-dimension contained the computed values of the statistics based on estimators that pooled the autoregressive coefficient across different countries for the unit root tests on the estimated residuals.

Table 3: Panel cointegration test results

	Within-Dimension				*Between Dimension*		
	Model 1 (inf = f(oilp, gdp,m2,exr)						
	v-stat	*p-stat*	*pp-stat*	*Adf-stat*	*p-stat*	*pp-stat*	*Adf-stat*
Exporting countries	1.307	-3.545***	-6.471***	-4.690***	-3.212***	-8.261***	-5.961***
Importing countries	0.056	-1.010	-2.487***	-1.488***	-0.695	-3.419***	-1.317***
	Model 2 (gdp = f(oilp, gfcf,enrl,m2)						
	v-stat	p-stat	pp-stat	Adf-stat	p-stat	pp-stat	Adf-stat
Exporting countries	0.775	-0607***	-2.224***	0.539***	0.266***	-2.163***	-0.453***
Importing countries	-1.182	0.438	-0.745	-0.453***	1.538	0.178	1.521
	Model 1 (inf = f(oilp, gdp,m2,exr)						
	v-stat	p-stat	pp-stat	Adf-stat	p-stat	pp-stat	Adf-stat
Exporting countries	-0127	0.729	0.121	-0.488	1.388	0.437	0.187
Importing countries	1.189	0.740	-0.184	0.221	1.33	0.603	0.633

Note: The test statistics are normalised so that the asymptotic distribution is standard normal.*,**,*** Indicate rejection of the null hypothesis of non-cointegration at the 10%, 5%, and 1% significance levels, based, respectively.

The columns labelled between-dimension report the computed values of the statistics based on estimators that averaged individually calculated coefficients for each country. Except for the v-statistic test, the results of the within-group tests and the between-group tests showed that the null hypothesis of no cointegration can be rejected.

Panel cointegration estimations

The cointegrating vector was estimated using two methods: the fully modified OLS and the dynamic OLS approaches. Tables 5 and 6 show the coefficients of the two methods for each country and the panel together. The data in tables 5 and 6 show the relationship among the selected variables in importing countries. The FMOLS and DOLS results indicated that oil price volatility had a positively significant effect on inflation in Kenya and a negatively significant effect on Cote d'Ivoire's inflationary rate. The result further showed that oil price volatility had negative and significant impact on the economic growth of Kenya and Morocco, but the reverse was the case for Cote d'Ivoire, as a positive and significant effect was found. The result also revealed that oil price volatility had negative and significant impact on the exchange rate behaviour of Kenya and Morocco, but had a positive and significant impact on the exchange rate behaviour of Senegal. Table 6 indicates that oil price volatility impacted Nigeria and Gabon's inflationary rate positively and this was found to be significant.

On the other hand, the effect of oil price volatility on economic growth, as shown in Table 6, indicates that the effect was positive and significant for Nigeria, Congo and Gabon. A closer examination of the data on the effect on exchange rate behaviour at the country level showed that oil price volatility only impacted positively and significantly on Nigerian and Gabon's exchange rate behaviour for the period under review. However, on the whole, the results showed that oil price volatility impeded inflationary rate in oil importing countries of Africa, as shown in the panel column of the results. This implies that oil price volatility did not contributed to inflationary rate in these countries, but the reverse was the case for its effect on inflation of oil exporting countries, as oil price volatility was found to facilitate inflationary rate.

Meanwhile, the data in Tables 5 and 6 showed that oil price volatility had negative and significant impact on exchange rate of oil importing countries; but this was not the case for oil exporting countries. For oil exporting countries, a positive and significant effect was found. The result further showed that oil price volatility had negative and significant impact on the economic growth of oil importing countries; for oil exporting countries, a positive and significant effect on economic growth was found.

Table 5: Empirical result for oil importing countries

	FMOLS					*DOLS*				
	Dependent variable: Inflation									
Regressors	*Kenya*	*Cote d'Ivoire*	*Senegal*	*Morocco*	*Panel*	*Kenya*	*Cote d'Ivoire*	*Senegal*	*Morocco*	*Panel*
OILP	0.05***	-0.09***	0.01	-0.02	-0.03*	0.00	0.01	-0.01	-0.01	-0.003*
GDP	0.17	0.05***	-0.11	-0.01	0.09*	-0.08	0.01	-0.02	0.06***	0.02*
M2	-0.40	0.01***	2.34	0.07	0.53*	0.52	0.10	0.85	0.27***	0.24**
EXR	-0.20***	-0.01	-0.15	-0.30	0.16**	-0.01	-0.04	-0.006	-0.08	0.001**
	Dependent Variable: GDP									
OILP	-6.37***	1.11***	0.10	-2.10***	-1.81**	2.69	3.87***	-0.01	-7.10***	-0.14*
GFCF	0.15	-1.46	-0.28	2.29***	0.012**	2.75	-0.43	0.86	-0.36	0.75**
ENRL	-4.53	0.01	-1.47	0.12***	-1.52*	11.01	0.24**	-1.76	-7.09	0.61**
M2	0.03***	-0.56***	7.15	0.04***	2.45***	0.05***	0.17***	9.28***	0.07***	2.45**
	Dependent variable: Exchange rate									
OILP	-2.21***	0.07	0.58***	-0.08***	-0.41**	-1.19***	0.02	0.14	-0.01	-0.26**
GDP	0.89	-0.01	-4.68***	0.06***	-0.96**	0.01***	0.17***	-5.89	0.21***	-1.23****
INFL	11.6	-4.47	-1.60	-1.52***	1.25***	-7.06	-1.20	-9.94	-0.02	4.23**
M2	34.01	0.42	102.67***	0.41***	35.23***	2.77	2.0	132.7***	0.12***	38.3**

Source: Authors compilation.

Note: *,**,*** Indicate significance of a variable at 10%, 5% and 1% significance levels, respectively

Table 6: Empirical result for oil exporting countries

	FMOLS					*DOLS*				
					Dependent variable: Inflation					
Regressors	*Nigeria*	*Algeria*	*Gabon*	*Congo*	*Panel*	*Nigeria*	*Algeria*	*Gabon*	*Congo*	*Panel*
OILP	0.07***	-0.01	0.04**	0.04	0.03**	0.01	0.07	0.07	0.01	0.04*
GDP	0.03	-0.15	0.21**	0.81	0.27**	0.12	0.57***	0.12	-0.15	0.19*
M2	-1.82***	0.30	-1.35	-0.91	-0.36**	-0.86*	0.12	-2.05***	-0.07	0.34*
EXR	-2.18***	-0.04	-0.40	0.67	-0.59**	-0.80***	-0.15	0.10	0.92*	0.04*
					Dependent Variable: GDP					
OILP	0.01***	5.89	2.17	5.83***	3.48	2.09***	5.74	1.56***	2.92***	3.07*
GFCF	2.09***	0.76	0.84	-3.67***	0.005**	5.71***	0.45*	1.36***	-2.50**	1.25***
ENRL	4.52	0.24***	-6.08***	1.35	0.007*	-0.08***	0.24***	-2.25	-2.08***	-1.04**
M2	0.18***	3.69	0.20***	0.23***	0.11*	0.15	0.14	0.26***	-1.86	-0.3
					Dependent Variable: Exchange Rate					
OILP	0.02*	0.08	0.05***	-0.01	0.04**	0.06	0.05	0.02*	-0.04	0.02**
GDP	0.12	0.59***	-0.37***	0.05***	0.09***	0.64	0.53***	-0.03***	0.23***	28.2**
INFL	-0.45***	0.93	-0.30	0.28*	0.13*	-0.40***	-2.12	0.52	0.19**	0.23**
M2	-0.55	5.47***	4.09	0.19	2.13**	-0.11	5.42***	5.20***	-0.27	2.12**

Source: Authors compilation

Note: *,**,*** Indicate significance of a variable at 10%, 5% and 1% significance levels respectively

Conclusion

This study examined oil price volatility and its effect on macroeconomic performance of eight African countries for the period 1980-2012. The countries were categorized into oil exporting and importing countries, applying recently developed panel cointegration methods. Three classes of panel unit root tests were used, while FMOLS and DOLS methods were used to deal with heterogeneity problems. The findings revealed that all the variables used in the study were stationary at first difference and a long-run relationship was established among them. Based on the findings, it can be concluded that oil price volatility impedes inflationary rate, economic growth rate and exchange rate behaviour of oil importing countries of Africa. However, it positively induces exchange rate, inflationary rate and economic growth rate of oil exporting countries. The findings are thus relatively in line with the demand side transmission channel postulated by Tang et al. (2010), as positive shocks to oil price volatility motivates variations in macroeconomic activities. Oil price volatility is, most times, uncontrollable by either the exporting or importing countries, as the factors of demand and supply dictate the turns in the market. It is however noteworthy that each economy should be protected against the adverse effect of such volatility through diversification of the sources of revenue generation against external shocks.

Reference

Afia Malik (2008). 'How Pakistan is Coping with the Challenge of High Oil Prices', MPRA Paper. Paper, 41413

Akpan E.O. (2009): Oil Price Shocks and Nigeria's Macroeconomy. A Paper Presented at the Annual Conference of CSAE Conference, Economic Development in Africa, 22nd-24th March, Oxford

Aliyu, S.U.R. 2009. Oil price shocks and the macroeconomy of Nigeria: a nonlinear approach. *Munich Personal RePEc Archive*

Ayadi O.F. (2005): Oil price fluctuations and the Nigerian economy. OPEC Review, Sept. 199-217

Ayadi O.F., Chatterjee A. and C.P. Obi (2000): A vector autoregressive (VAR) analysis of an oil-dependent emerging economy - Nigeria, OPEC Review, December, 329–49.

Backus D.K. and Crucini M.J. (2000): Oil prices and the terms of trade. Journal of International Economics 50:185-213.

Bernanke B., Gertler M. and M. Watson, (1997): Systematic Monetary Policy and the Effect of Oil Price Shocks, Brookings Papers on Economic Activity 1: 91-142.

Breitung, J., 2000. The local power of some unit root tests for panel data. In: Baltagi, B. (Ed.), Nonstationary Panels, Panel Cointegration, and Dynamic Panels. Advances in Econometrics, vol. 15. JAI, Amsterdam, pp. 161–178.

Chen, S.-S., H.-C., Chen. 2007. Oil prices and real exchange rates. *Energy Economics Journal* 29: 390-404.

Farzanegan M.R. and G. Markwardt (2009): The Effects of Oil Price Shocks on the Iranian Economy. *Energy Economics* 31(1): 134-151

Hamilton J.D. and A.M. Herrera (2001): Oil Shocks and Aggregate Macroeconomic Behavior: The Role of Monetary Policy, *Mimeo*, Dept of Economics, University of California, San Diego.

Khan, B., Ahmed.and Ali, Mubashir, Syed. (2000). 'Energy Policy in Pakistan: An Investigation of The Tariff Structure of Petroleum Products'. Working Paper No. 00-24. Centre for Management and Economic Research, Lahore University of Management Sciences, Lahore.

Kilian, L. (2009). Comment on 'Causes and consequences of the oil shock of 2007-08' by J.D. Hamilton. *Brookings Papers on Economic Activity*, 1, Spring; 267-278

Korhonen, I., A., Mehrotra. 2009. Real exchange rate, output and oil: Case of four large energy producers. *BOFIT*.

Latife, G. (2011). 'The Interaction between Oil Price and Economic Growth', Middle Eastern Finance and Economics.Issue 13.

Larsson, R., J., Lyhagen, M., Lothgren. 2001. Likelihood-based cointegration tests.

Levin, A., Lin, C.F., 1993. Unit Root Tests in Panel Data: New Results. Discussion Paper.Department of Economics, UC-San Diego.

Levin, A., Lin, C.F., Chu, C., 2002. Unit root test in panel data: asymptotic and finite sample properties. Journal of Econometrics 108 (1), 1–24.

Maddala, G.S., Wu, S., 1999. A comparative study of unit root tests with panel data and new simple test. Oxford Bulletin of Economics and Statistics 61, 631–652.

Mork, K.A. 1989. Oil shocks and the macroeconomy when prices go up and down: an extension of Hamilton's results. Journal of Political Economy 97: 740–744.

Mork, K.A., Oslen, O. and Mysen, H. 1994. Macroeconomic responses to oil price increases and decreases in seven OECD countries. Energy Economics Journal 15: 19-35.in heterogeneous panels. Econometrics Journal 41: 109–142.

Muhammad BachalJamali, Asif Shah, Hassan JawadSoomro, Kamran Shafiq and FaizM.Shaikh, (April 2011). 'Oil Price Shocks: A Comparative Study on the Impacts in Purchasing Power in Pakistan'. Modern Applied Science Journal.Vol.5, No. 2.

Pedroni, P. 2004. Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to PPP hypothesis. *Econometric Theory* 20: 597–625.

Pesaran, M.H., 2005. A simple panel unit root test in presence of cross section dependence Cambridge University Working Paper.

Pesaran, H., Smith, R., 1995. Estimating long-run relationships from dynamic heterogeneous panels. Journal of Econometrics 68, 79–113.

Pesaran, H., Shin, Y., Smith, R., 1999. Pooled Mean Group estimation and dynamic heterogeneous panels. Journal of the American Statistical Association 94, 621–634.

Rautava, J. 2004. The role of oil prices and the real exchange rate in Russia's economy – a cointegration approach. Journal of Comparative Economics 32: 315-32

West African Monetary Agency (2008): Impact of Petroleum Price Fluctuations on Key Convergence Criteria in ECOWAS member states.