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RESEARCH ARTICLE

Crude Oil, Exchange Rate and the Convergence of Foreign Reserves: A VECM of Nigeria's Monetary Policy Tools

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Abstract

Nigeria's high level dependence on crude oil for its foreign exchange earnings makes its capital account vulnerable to the crude oil price fluctuations. In addition to this, are the high import bills which also contributed to the fluctuations in the total external reserves level over the years. This Paper focus on the interaction among selected monetary variables-crude oil price, exchange rate and external reserves over the period of 1970-2014, using long-run VECM and the short run Granger Causality/Block Exogeneity Wald tests. VEC test indicates a self-adjusting mechanism for correcting any deviation of the variables from equilibrium. It insinuated that external reserves will converge back to steady state in 5 years, Crude oil price in approximately 4 years, while foreign exchange rate will return to its steady state in 96 years. This is due to Nigeria's over-dependent on imported products, foreign medical tourism, and the effect of declining oil price, stock market speculation and capital flight. In order to correct the disequilibrium of the external reserves, cointegrating long run equation shows that a 1% increase in crude oil price will lead to 1.8% increase in external reserves.

Keywords: *Foreign exchange reserves, Price volatility, Steady state.*
JEL classification: C54, C55, C22, E37, E52

Introduction

The oil boom of the mid-1970s has resulted in the build-up of foreign exchange reserves which were diversified into an array of financial instruments-foreign government bonds and treasury bills, fixed term deposits, foreign government guaranteed securities, Special Drawing Rights (SDRs), and current accounts. This provided significant liquidity and investment income to the country. The glut in the global oil market however led to the collapse in the price of crude oil and subsequently drained the reserves. Fig 1 demonstrates the relationship between the external reserves and crude oil price.

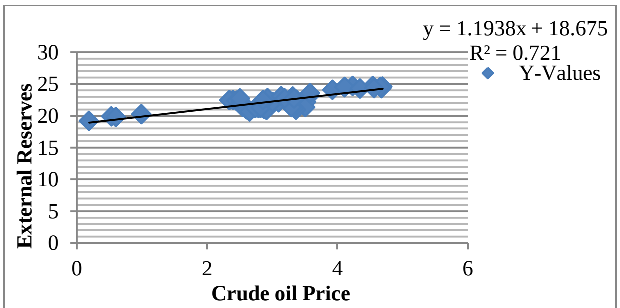

Figure 1: Correlation between external reserves and crude oil price
Source: Author's Estimation using Eviews 7.1.

The above figure estimates the future crude oil price and total external reserves with the use of existing data of 1970-2014 obtained from World Bank. The linear regression shows a strong relationship between the two variables. The closer the data to the trend line, the closer the relationship and R^2 of 0.721 (72.1%) explain the reliability of the data. The evolution shows a positive relationship, an increase in crude oil price led to an increase in foreign reserves during the analyzed period. Crude oil price rose from \$25.6 to \$138.76 per barrel in 2008 pre-crisis period, thus leading to an upsurge of the external reserves from \$5.8 billion to \$62.1 billion. During the global crisis, the downward sloping of the crude oil price depleted the external reserves to an average of \$46.5 billion. In the post crisis, the price of crude oil has been below \$50 per barrel, and external reserves has suffers continues decline, recording only \$30 billion as of November 26th, 2015 [1]. Even Saudi Arabia -OPEC's and world's largest oil producer is caught in the declining oil situation.

Saudi Arabia began to sell its external reserves to support its budget deficit and defend the Riyal (Saudi Arabia's currency). In October, the world's largest oil exporter saw net foreign assets drop by $90.5 billion year-on-year, after registering total reserve assets of $647.8 billion [2], the biggest year-on-year drop on record this year.

For 2016, OPEC has adjusted downward its growth estimation for world oil demand by 40 thousand barrels per day, mainly to reflect a high baseline effect in OECD Americas. World oil demand growth is now estimated to be 1.25 million barrel per day, with total global consumption at around 94.11 million barrel per day. European oil demand remained strong for another month, with increases of around 0.3 million barrel per day in August year-on-year; the majority of countries in the region saw positive demand growth [3]. Chinese oil demand for 2016 is expected to be in the range of 0.30 million barrel per day.

Going forward for this analysis, the next section reviews some relevant litratures, while section 3 contain the methodology and detail analysis of this study and concluded in the 4th section.

Literature Review

Foreign exchange reserves have been significantly volatile and quite rapidly taking a nose dive in recent years across the globe due to exchange rate shock in natural resource countries, especially in crude oil producing countries. This has led scholars in evaluating crude oil price shock implications on macroeconomic parameters. Arezki, Dumitrescu, Freytag, & Quintyn [3] examined the relationship between South African Rand and gold price volatility, and their findings suggest that gold price volatility plays a key role in explaining both the excessive exchange rate volatility and current disproportionate share of short-run speculative. Shuaibu & Mohammed [4] analyzed the determinants and sustainability of external reserve accumulation, and the effects of external reserves on exchanges and inflation. Their empirical result shows that variability of export earnings and the value of international reserves positively affect reserve holding while oil price negatively have a long-run effect. Meanwhile, Umeora investigated how changes in macroeconomics variables influence foreign reserves. Previous studies also evaluated the relationship between oil price shock and current account balances [4]; the impact of external reserve variability on investment, inflation and exchange rate [5]; and the effect of crude oil price and other macroeconomic variables on real external reserves [6]. Early this year, Imarhiagbe researched the impact of crude oil price on the conditional mean and volatility of external reserves from January 1995 to December 2013, using the GARCH-M and EGARCH-M model. Other study had gone further to evaluate foreign reserves and macroeconomic variables [7]; the macroeconomic effects of crude oil and food price shocks in Asia and Pacific economies [8].

They employed SVAR model, which reveals a mild impacts of crude oil price on economic activities after the 1980s. Exceptions are resource-poor countries that specialize in heavy manufacturing industries, like Korea and Taiwan, which are the most affected.

In order to strengthen the international financial architecture, the International Monetary Fund has developed guidelines for Foreign Exchange Reserve Management [9], to promote policies and practices that contribute to stability and transparency in the financial sector and to reduce external vulnerabilities of member countries. The guidelines created a sound reserve management practices that are important to increase a country's or regions' overall resilience to shocks. A weak or risky reserve management practices can however led to a significant financial and reputational costs.

In view of the dominant role of crude oil revenue in the Nigerian economic activities, the investigation of the crude oil price, exchange rate and external reserves relationship has important implications for the Nigeria's economic development.

Methodology

This paper uses a Vector Auto Regression to identify the relationship between Nigeria's external reserves, exchange rate and crude oil price. The empirical investigation is based on sample covering the period of 1970 to 2014.

Model Specification

ER = f (COP, FX) ....(1)

In an explicit and econometric form, equation (1) can be stated as:

$ER_t = \beta_0 + \beta_1 COP_t + \beta_2 FX_t + \varepsilon_t$ ....(2)

Where; ER_t is External reserves – holdings of monetary gold, special drawing rights held by the IMF, and holdings of foreign exchange under the control of the Central Bank of Nigeria. COP_t is the crude oil price in the international market and FX_t is the annual average averages official exchange rate of the naira (Nigerian currency) in relative to the U.S. dollar. β_0 is the constant term called the intercept and, β_1 and β_2, are the coefficients of the regression equation. "t" is the time trend, and "ε_t" is the stochastic random term. Data used for this analysis is for 44 years from 1970 to 2013 for Nigeria from World Development indicators (2015), World Bank website and the crude oil price from [10].

Estimation Technique

The structural approach to time series data that this study adopted uses economic theory to model the relationship among the variables of interest. Since estimation and inference are complicated by the fact that endogenous variables may appear on both sides of equations. This has led to alternative, non-structural approaches to modeling the relationship among several variables. We investigated the time series characteristics of the data to test whether the variables are integrated. In order to test the analyzed stationary variables, Augmented Dickey-Fuller (hereafter as ADF) test and Philip and Perron (hereafter as P-P) will be applied. Given an observed time series Y_1, $Y_2 \ldots Y_N$, Dickey and Fuller consider three differential-form autoregressive equations to detect the presence of a unit root.

The theory behind Autoregressive–moving-average (hereafter as ARMA) estimation is based on stationary time series. A series is said to be (weakly or covariance) stationary if the mean and autocovariances of the series do not depend on time. A common example of a nonstationary series is the random walk:

$$y_t = y_{t-1} + \epsilon_t$$

Where ϵ is a stationary random disturbance term. The series y has a constant forecast value, conditional on t, and the variance is increasing over time. The random walk is a difference stationary series since the first difference of y is stationary:

$$y_t - y_{t-1} = (1 - L)y_t = \epsilon_t$$

A difference stationary series is considered to be integrated, this series is denoted as I(d) where d is the order of integration. The order of integration is the number of unit roots contained in the series, or the number of differencing operations it takes to make the series stationary. For the random walk above, there is one unit root, so it is an I(1) series. Similarly, a stationary series is I(0).

Table 1: Unit root test at level

		ADF			P-P		
		LCOP	LER	LFx	LCOP	LER	LFx
t-statistic		-2.631	-1.935	-0.291	-2.631	-1.905	-0.387
Test critical values:	1% level	-3.586	-3.589	-3.589	-3.589	-3.589	-3.589
	5% level	-2.930	-2.930	-2.930	-2.930	-2.930	-2.930
	10% level	-2.603	-2.603	-2.603	-2.603	-2.603	-2.603

Source: Author's Estimation using Eviews 7.1.

Table 1 reveals all the variables (with the exception of LCOP at 10% level) to be non-stationary at levels, in both ADF and PP test statistics with the critical values at the 1%, 5% and 10% level of significance. Notice here that the critical values for LCOP, LER and LFX are greater than the statistic $t_\alpha$value so that we can reject the null at conventional test sizes. As a consequence of the non-stationarity of the time series data, which is unforeseeable and might result in a spurious finding when modeled or forecasted. For consistent reliable results, the solution to the above situation is to transform the data so that it becomes stationary. Table 2 discloses a first difference result of the variables.

Table 2: Unit root test at 1st difference

		ADF			P-P		
		LCOP	LER	LFx	LCOP	LER	LFx
t-statistic		-6.277	-5.555	-5.296	-6.278	-6.318	-5.299
Test critical values:	1% level	-3.592	-3.597	-3.592	-3.592	-3.592	-3.592
	5% level	-2.931	-2.933	-2.931	-2.931	-2.931	-2.931
	10% level	-2.604	-2.605	-2.604	-2.604	-2.604	-2.604

Source: Author's Estimation using Eviews 7.1.

All the variables in both ADF and P-P unit root test at 1st difference have been transformed. As a result, we can reject the null hypothesis of unit root and we can safely conclude that the variables are stationary. After testing the variables are stationary at first order or I(1), then the next step is to estimate the Vector Error-correction Model (VECM). After estimating the long-run VECM model, then we can proceed to the short run Granger Causality/Block Exogeneity Tests. However, we need to select an optimum lag of VECM model before performing the Johansen cointegration test.

The last two columns reported in table 3 are the Ljung-Box Q-statistics and their p-values. The Q-statistic at lag is a test statistic for the null hypothesis that there is no autocorrelation up to order and is computed as:

$$Q_{LB} = T(T+2)\sum_{j=i}^{k}\frac{\tau_j^2}{T-J}$$

Where T is the number of observations and τ_j is the *j-th* autocorrelation. If the series is not based upon the results of Autoregressive Integrated Moving Average (hereafter as ARIMA) estimation, then according to the null hypothesis, Q is asymptotically distributed as a x^2 with degrees of freedom equal to the number of autocorrelations. If the series represents the residuals from ARIMA estimation, the appropriate degrees of freedom should be adjusted to represent the number of autocorrelations less the number of autoregressive and moving-average terms previously estimated [11].

Table 3: Autocorrelation

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |*. |	. |*. |	1	0.094	0.094	0.4132	0.520
**| . |	**| . |	2	-0.263	-0.274	3.7341	0.155
.*| . |	. | . |	3	-0.071	-0.016	3.9862	0.263
.*| . |	.*| . |	4	-0.070	-0.144	4.2357	0.375
. |*. |	. |*. |	5	0.135	0.149	5.1787	0.394
. |*. |	. | . |	6	0.149	0.064	6.3623	0.384
.*| . |	.*| . |	7	-0.108	-0.071	6.9961	0.429
**| . |	.*| . |	8	-0.209	-0.151	9.4528	0.306
.*| . |	.*| . |	9	-0.087	-0.080	9.8955	0.359
. |*. |	. |*. |	10	0.177	0.127	11.765	0.301
. |*. |	. | . |	11	0.142	0.028	12.998	0.293
**| . |	**| . |	12	-0.254	-0.265	17.091	0.146

<table>
<tr><td>.*| . |</td><td>.*| . |</td><td>13</td><td>-0.195</td><td>-0.086</td><td>19.581</td><td>0.106</td></tr>
<tr><td>.*| . |</td><td>.*| . |</td><td>14</td><td>-0.082</td><td>-0.133</td><td>20.040</td><td>0.129</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>15</td><td>0.044</td><td>-0.012</td><td>20.172</td><td>0.165</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>16</td><td>0.169</td><td>-0.020</td><td>22.247</td><td>0.135</td></tr>
<tr><td>. |*. |</td><td>. |*. |</td><td>17</td><td>0.090</td><td>0.088</td><td>22.858</td><td>0.154</td></tr>
<tr><td>**| . |</td><td>.*| . |</td><td>18</td><td>-0.230</td><td>-0.162</td><td>26.974</td><td>0.079</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>19</td><td>-0.077</td><td>0.048</td><td>27.455</td><td>0.094</td></tr>
<tr><td>. | . |</td><td>**| . |</td><td>20</td><td>-0.008</td><td>-0.215</td><td>27.461</td><td>0.123</td></tr>
</table>

Source: Author's Estimation using Eviews 7.1.

The autocorrelation of the error terms in each regression is checked by using the Ljung-Box Q-statistic. The Q-statistic reveals that the error terms are statistically significant from lag 1, where the p-value is greater than 0.05. This implies that the regression residuals does not have autocorrelation problem. Having satisfied the stationarity of the variables at I(1) and obtaining the optimum lag, we will proceed to determine the long run relationship of the variables, since regression with I(1) data only makes sense when the data are cointegrated. The Johansen's methodology of multivariate cointegration test at 2 lag intervals in first difference with linear deterministic trend is employed

Table 4a: Unrestricted cointegration rank test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.408298	44.09183	29.79707	0.0006
At most 1 *	0.377696	22.05226	15.49471	0.0044
At most 2	0.049463	2.130577	3.841466	0.1444

**MacKinnon-Haug-Michelis (1999) p-values

Table 4b: Unrestricted Cointegration rank test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.408298	22.03957	21.13162	0.0372
At most 1 *	0.377696	19.92168	14.26460	0.0057
At most 2	0.049463	2.130577	3.841466	0.1444

**MacKinnon-Haug-Michelis (1999) p-values

Engle and Granger [8] revealed that cointegration implies the existence of an error correction model of the form that describes the dynamic behavior of ΔER in the case of this study. The error correction model links the long-run equilibrium relationship implied by cointegration with the short-run dynamic adjustment mechanism that describes how the variables react when they move out of long-run equilibrium. Table 4a & b present the Johansen-Juselius Cointegration test at Lags interval in first differences with linear deterministic trend. The result shows that both tests indicated 2 cointegrating equations at the 0.05 level. Therefore, both Trace test and Maximum Eigenvalue test are statistically significant to reject the null hypothesis of $r = 0$ at 5% significance level.

Since the set of variables are found to have two cointegrating vectors, then a suitable estimation technique is a VECM (Vector Error Correction Model) which adjusts to both short run changes in variables and deviations from equilibrium. The intuition is that I(1) time series with a long-run equilibrium relationship cannot drift too far apart from the equilibrium because economic forces will act to restore the equilibrium relationship.

Table 5: Vector error correction model

Error Correction:	D(LER)	D(LCOP)	D(LFX)
CointEq1	0.196666 (0.12592) [1.56183]	0.259665 (0.05862) [4.42929]	0.010401 (0.05207) [0.19974]

Source: Author's Estimation using Eviews 7.1.

Theoretically speaking, the speed of adjustment parameters α (Y) (the coefficients on "cointeq1") should be negative and lie between (0, -1). According to VEC model, the point estimate should imply that output (Y) in time "t" converges to the long-run equilibrium relationship – if Y is above its long-term value (ECM term >0), Y must decline (α(Y) <0) and if Y is below its long-term value (ECM term <0), Y must rise (α(Y) <0). Therefore, the negative signs of the estimated coefficient of the variables imply that the series cannot drift too far apart, and convergence will be achieved in the long run.

The estimated coefficient of the log of external reserves (0.196666) shows the speed at which it converge to it long run equilibrium (Steady state). This means that, 19.7% of this disequilibrium is corrected in 1 year. The 0.259665 estimated coefficient of LCOP, is implying that crude oil price is diverging from its steady state by ~26% each year. The Naira/Dollar exchange rate estimated coefficient also suggested that the exchange-rate regime is diverging from steady state and require converging back to equilibrium with 0.010401 estimated coefficient. Below is the cointegrating long run equation with all variables positively significant at 5% significance level:

LER= 16.61961+1.801562 LCOP + 0.042599 LFX		
S.E	(0.23968)	(0.09202)
t-Statistic	[-7.51661]	[-0.46292]

With the cointegration, the dynamic causal interactions between the variables ought to be expressed in a VEC form. With this, we can evaluate both long-run and short-run causality, respectively, on the □□□-test of the lagged first differenced terms for each right-hand-side variable and the t-test of the error correction term. The summary results of the test are presented in Table 6.

Table 6: Granger causality results based on VECM

Dependent Variable	Independent Variables □□-Statistics of lagged 1st differenced term [p-value]			ECTt-1 coefficient (t-ratio)
	ΔLER	ΔLCOP	ΔLFX	
ΔLER	-	0.849 [0.654]	0.103 [0.950]	0.197 [1.562]
ΔLCOP	8.076 [0.018]	-	1.621 [0.445]	0.260 [4.429]
ΔLFX	4.806 [0.091]	13.487 [0.001]	-	0.010 [0.200]

Source: Author's Estimation using Eviews 7.1.

Meanwhile, unidirectional granger causality runs independently from FX rate to COP, and from COP to ER. Also both determinants variables(ER & COP) taken together also granger cause Foreign exchange in the short run [12-18].

Conclusion

This study focuses on the interactions among selected monetary policy variables, namely Crude oil price, Foreign exchange rate and External reserves of Nigeria. The dataset covered the period of 1970-2014, using long-run VECM model and the short run Granger Causality/Block Exogeneity Wald Tests to find their relationship and the time of convergent. The unit root result reveals that the variables are integrated of order one I(1). VEC test indicates a self-adjusting mechanism for correcting any deviation of the variables from equilibrium. It insinuated that external reserves will converge back to steady state in 5 years. Crude oil price has also diverged from its equilibrium and will converge back in approximately 4 years, while foreign exchange rate will return to its steady state in 96 years. This is due to Nigeria's over dependent on imported merchandise, foreign medical tourism, the effect of declining oil price, stock market speculation, the new trend of students going abroad for studies and capital flight. In order to correct the disequilibrium of the external reserves, cointegrating long run equation shows that a 1% increase in Crude oil price will lead to 1.8% increase in Nigeria's external reserves. Meanwhile, 1% increases in the value of naira in exchange with the United States dollar will only increase the external reserves by 0.04%.

Reference

1. Abdullateef U, Waheed I (2010) External reserve holdings in Nigeria: Implications for investment, inflation and exchange rate. Journal of Economics and International Finance, 2(9):183-189.
2. Alom F, Ward BD, Hu B (2013) Macroeconomic effects of world oil and food price shocks in Asia and Pacific economies: application of SVAR models. OPEC Energy Review, 37(3):327-372.
3. Arezki R, Dumitrescu E, Freytag A, Quintyn M (2012) Commodity Prices and Exchange Rate Volatility: Lessons from South Africa's Capital Account Liberalization. IMF Working Paper.
4. Shuaibu MI, Mohammed TI (2014) Determinants and Sustainability of International Reserves Accumulation in Nigeria. Zagreb International Review of Economics & Business, 17(1):27-46.
5. Audu NP, Okumoko PT (2013) The dynamic of Nigeria's foreign reserve: A time series approach. Indian Journal of Economics and Business, 12(2-4):201-222.
6. CBN (2015, November 26). The Movement in Reserves (30-Day Moving Average with effect from November 2011). Retrieved November 29, 2015, from Central Bank of Nigeria: www.cenbank.org/IntOps/Reserve.asp
7. Chuku CA, Akpan UF, Ndifreke SR, Ekpeno EL (2011) Oil price shocks and the dynamics of current account balances in Nigeria. OPEC Energy Review, 35(2). doi:10.1111/j.1753-0237.2011.00186.x
8. Engle RF, Granger C (1987) Co-integration and Error Correction: Representation, Estimation, and Testing. Econometrica, 55(2):251-276.
9. IHS Global Inc. (2015, November 16). Correlogram. Retrieved November 22, 2015, from E Views: www.eviews.com/help/helpintro.html#page/EViews%209%20Help/series.017.07.html
10. Imarhiagbe S (2015) Examining the Impact of Crude Oil Price on External Reserves: Evidence from Nigeria. International Journal of Economics and Finance, 7(5), 13-21.
11. IMF (2001, September 20). Guidelines for Foreign Exchange Reserve Management. Executive Board. International monetary fund. Retrieved November 29, 2015, from www.imf.org/external/np/mae/ferm/eng/
12. Olokoyo FO, Osabuohien ES, Salami AO (2009) Econometric Analysis of Foreign Reserves and Some Macroeconomic Variables in Nigeria (1970-2007). African Development Review, 21(3):454-475.
13. OPEC (2015) OPEC Basket Price (Yearly) Retrieved November 22, 2015, from:www.opec.org/opec_web/en/data_graphs/40.htm
14. OPEC (2015) OPEC Monthly Oil Market Report - October 2015. Vienna, Austria: Organization of the Petroleum Exporting Countries. Retrieved November 8, 2015
15. SAMA (2015, October). Monthly Statistical Bulletin. Retrieved November 29, 2015, from Saudi Arabian Monetary Agency: www.sama.gov.sa/en-US/EconomicReports/Pages/MonthlyStatistics.aspx
16. Umeora CE (2013) Accumulation of External Reserves and Effects on Exchange Rates and Inflation. International Business and Management, 6(2):105-114. doi:10.3968/j.ibm.1923842820130602.1155
17. Worl Bank (2015) Official exchange rate (LCU per US$, period average). Retrieved November 22, 2015, from http://data.worldbank.org/indicator/PA.NUS.FCRF
18. World Bank (2015) Total reserves (includes gold, current US$). Retrieved November 22, 2015, from http://data.worldbank.org/indicator/FI.RES.TOTL.CD