Oil Price Pass-Through into Inflation: Empirical Evidence from Nigeria

Adeniyi O. Adenuga, Margaret J. Hilili and Osaretin O. Evbuomwan*

Abstract

The petroleum industry is a major driver of the Nigerian economy. Its importance has become even more noticeable in terms of its revenue generation capability for economic development as well as the multiplier effects of its downstream activities. However, due to its global significance, the sector has experienced fundamental changes and challenges. Against this background, this work is motivated by the fact that Nigeria relies heavily on crude oil export revenues, which represents about 90.0 per cent of total export earnings and on average about 70.0 per cent of government revenues in its annual budgets, thereby making it vulnerable to the vagaries of the international oil market. The monetisation of these oil proceeds affect money supply and consequently, the general price level. The objective of the paper therefore is to empirically investigate the oil price pass-through into inflation in Nigeria in order to suggest appropriate domestic policies necessary to control inflation for the policy makers. The study also attempts to answer questions like: What is the causal links between oil price and inflation in Nigeria? Is oil price highly correlated with inflation? What does the result of an estimation of a Phillips curve tell us about the pass-through for oil in Nigeria. The methodology adopted by the paper is a standard pass-through equation in the form of an autoregressive distributed lag (ARDL) model and quarterly series from 1990 - 2010 were used for the estimation. The estimation results indicate that changes in oil price have had significant effects on inflation. Other findings are that inflation has been influenced by exchange rate changes and changes in broad money supply and maximum lending rate.

Keywords: Oil, Pass-through, Inflation, Nigeria

JEL Classification Numbers: *C01, C13, C22, E31*

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I. Introduction

The petroleum industry is a major driver of the Nigerian economy. In the past years, its importance has become more noticeable in terms of its revenue generation capability for economic development as well as the multiplier effects of its downstream activities. These manifested in the areas of industrialization through the provision of industrial inputs, employment generation as well as energy for productive purposes. Major projects have been financed from the revenue derived from the sub-sector, such as the steel complexes, refineries and petrochemical, fertilizer, and aluminum smelter plants as well as social infrastructure. However, due to its global significance, the sector has experienced dynamism and challenges. These include among others, the oil price shocks of the early 1970s, which was accentuated when crude oil pricing decision, usually taken by the international oil companies, was ceded to the Organisation of Petroleum Exporting Countries (OPEC). The initial increase in the oil price by exporting countries led to a cut in demand and eventual global economic depression. The resultant fall in oil prices culminated in the large drop in oil revenue of the exporting countries, including Nigeria in the 1980s. As a result of these developments, many projects and programmes embarked upon during the oil boom period remained uncompleted while the maintenance of those completed faced funding challenges (Ojo and Adebusuyi, 1996).

Over the years, developments in the global economy have constituted a challenge to policy makers, particularly in oil exporting countries. This is reflected in the increasing spate of fluctuations in crude oil prices in the international oil market. For example, the spot price of Nigeria's reference crude, Bonny Light (37^0 API) oscillated between US$10.22 per barrel in February and US$25.75 per barrel in December in 1999. It ranged between US$30.99 and US$49.91 per barrel in 2004. In fact, the average price of oil has witnessed profound fluctuations from US$17.35 per barrel in 1999 to US$101.15 in 2008, US$62.08 in 2009 and US$80.81 per barrel in 2010. The slump in the average price of oil in 2009 caused a large contraction in the value of Nigeria's oil exports to US$44.50 billion, from US$82.00 billion in 2008 (Central Bank of Nigeria Annual Reports (various issues)). Import growth declined, owing to the fall in international oil price and low domestic demand. Persistent oil price changes could have more severe macroeconomic implications, thus inducing challenges for policy making in both the oil exporting and oil importing countries (Hooker, 1996; Daniel, 1997 and Cashin et al, 2000). These studies support the assertion that oil price being a key determinant of the price of many goods in the consumer basket, would impact on inflation directly when it changes. The studies, suggest, therefore, that rising oil prices reduced output and increased inflation in the 1970s and early 1980s while falling oil prices boosted output and lowered inflation particularly, in the U.S in the mid-to-late 1980s. The substantial increase in the volatility of oil prices over the past decade in Nigeria and its impact on inflation rate and some other macroeconomic variables has provoked great concerns for policy makers.

Analysis of inflation in Nigeria from 2000 to 2010 showed that, it was double-digit all-through from 14.5 per cent in 2000, rising to 23.8 per cent in 2003. However, the inflationary pressure decelerated to 8.5 per cent and 6.6 per cent in 2006 and 2007, respectively before assuming an upward trend to peak at 15.1 per cent in 2008. It fell to 13.9 and 11.8 per cent in 2009 and 2010, respectively. The high inflation in 2003 was attributed to the rise in aggregate demand occasioned by the tempo of political activities (general elections), the depreciation of the naira, and increase in the pump prices of petroleum products.

From the literature, a few studies focus on changes in the degree of oil price pass-through. Hooker (2002) estimates a Phillips curve model with quarterly data from 1962:Q2 to 2000:Q1. He finds that oil price pass-through has become negligible since 1980. LeBlanc and Chinn (2004) also utilise Phillips curve framework to investigate the G5 countries, and obtain similar findings that current oil price increases are likely to have a modest effect on inflation in the U.S., Japan, and Europe. De Gregorio, et al. (2007) show evidence of a substantial decline in oil price pass-through using both a Phillips curve model and a rolling VAR model. They submit that a decline in oil price pass-through is a generalized feature of any of the 34 developed and developing countries considered.

From the above studies, the evidence appears mixed. For instance, Hooker (2002) shows that declining energy intensity is not the major cause of declining pass-through in the U.S. economy, whereas Gregorio, et al. (2007) using a similar specification for 24 industrial countries conclude that the fall in energy intensity helps explain the decline in average pass-through.

Most of the existing studies for Nigeria were on oil price shock and macroeconomic activities in Nigeria as well as oil price distortions and their short and long-run impact on the Nigerian economy (Olomola and Adejumo, 2006; Chuku, Effiong and Sam, 2010; Ayadi, 2005; Akpan, 2009; Aliyu, 2009 and Adebiyi, et. al., 2009). The work is motivated by the fact that Nigeria relies heavily on crude oil export revenues, which represents about 90 per cent of total export earnings and on average about 70 per cent of government revenues in annual budgets. In addition, Nigeria has witnessed a sudden decline in oil prices from the peak of US$141.26 per barrel in July 2008 to US$45.64 in January 2009. The development reflected severe implications for the Nigerian economy. It is, therefore, vital to empirically investigate the oil pass-through into inflation in Nigeria in order to suggest appropriate domestic policies necessary to control inflation for the policy makers.

These questions arise: What is the causal link between oil price and inflation in Nigeria? Is oil price highly correlated with inflation? What does the result of an estimation of a Phillips curve tell us about the pass-through for oil in Nigeria? All these questions are relevant and germane to this paper. The objective of the paper therefore, is to examine the oil price-inflation nexus in Nigeria and determine whether pass-through is comparable with those reported in recent studies on other economies. The relevance of this research to policy formulation particularly in an oil-producing economy like Nigeria is to deepen the understanding of the transmission of pass-through of oil price to inflation in order to help monetary authorities anticipate the effects of such fluctuations on inflation. The methodology adopted by the paper is a standard pass-through equation in the form of an autoregressive distributed lag (ARDL) model and quarterly series from 1990 - 2010 were used for the estimation.

In Nigeria, the relationship between the price of oil and inflation as well as the price of oil and exchange rate are shown in figures 1and 2 in the appendix for the period 2000 - 2010. In figure 1, inflation witnessed peaks in three periods - 2001, 2003 and 2008, while it declined to low ebbs in 2002, 2004 and 2007, respectively. When oil prices are declining and the supply side of the economy is constrained by infrastructure, drought and small-scale farming pushes food prices upward leading to cost push inflation. This scenario occurred during 2000 - 2003. In spite of the efforts to achieve debt sustainability, sterilization of foreign exchange earnings and ensuring a commitment to oil price rule, headline inflation was relatively high, complementary disinflationary policies that characterized the period of the oil boom of 2004-2008 helped in reducing inflationary pressure. The spike in inflation in the era of the boom was largely occasioned by the acceleration in government spending following the monthly disbursements of oil revenue. The process involves the monetization of foreign exchange earnings leading to the jump in banking sector deposits and the attendant liquidity expansion.

From figure 2, there is a strong correlation between the movement in international oil price and the exchange rate of the Naira. It depicts that the exchange rate depreciates when the international price of oil is declining. Similarly, when the international oil price is rising the pressure on the exchange rate reduces and the currency shows signs of appreciation. This latter instance could be deciphered from 2008 and 2009.

The correlation between inflation and oil prices in domestic currency (i.e. dollar prices per barrel multiplied by the nominal exchange rate) is -0.386; the correlation between inflation and oil prices in dollar values is -0.383 while that between inflation and the exchange rate is -0.172. Therefore, it could be deduced that oil price is inversely correlated with inflation (figure 1).

Following this introduction, the rest of the paper is organized as follows: Section 2 provides the empirical literature review and the theoretical framework. Section 3 describes the methodology, covering the sources of data, scope, characteristics of variables and model specification. Empirical findings and analysis are discussed in section 4, while the policy implications and conclusion are contained in section 5.

II. Empirical Literature Review and Theoretical Framework

II.1 Empirical Literature Review

Over the years, a considerable amount of economic studies have embarked on exploring the relationship between oil price shocks and the aggregate performance of various national economies. These studies have centered on two main research perspectives. One line of research tries to quantify the impact of oil price changes on inflation and output. In recent times, increased attention has been focused on this subject due to the decline in the effect that spikes in oil prices have on inflation in both industrial and emerging economies.

Hooker (2002), De Gregorio, et al. (2007), Blanchard and Gali (2007), and Shioji and Uchino (2010) made similar conclusions that oil price pass-through has declined in a number of countries such as the US, Japan and other industrialized countries. They attributed the developments to the intensity with which oil is used in production in those countries, improved monetary policy, greater wage flexibility and the presence of off-setting shocks. In a similar study, Olomola and Adejumo (2006) analyzed the impact of oil price shocks on aggregate economic activity – output, inflation, the real exchange rate and money supply – in Nigeria using quarterly data from 1970 to 2003. The study, which made use of VAR techniques revealed that oil price shocks do not significantly affect output and inflation in Nigeria but significantly affected money supply in the long-run, therefore, suggesting the tendency of "Dutch Disease".

Akpan (2009) analyzed the relationship between oil price shocks and the Nigerian economy using the VAR approach. The study pointed out the asymmetric effects of oil price shocks; for instance, positive as well as negative oil price shocks significantly increase inflation and also directly increases real national income through higher export earnings, though part of this gain is seen to be offset by losses from lower demand for exports generally due to the economic recession suffered by trading partners. Furthermore, the findings of the study observed the "Dutch Disease" syndrome through significant real effective exchange rate appreciation.

On the contrary, Berument and Tasci (2002) investigated the effects of oil prices in Turkey and found that when wages and other three factors of income (profit, interest and rent) are adjusted to the general price level that include oil price increases, the inflationary effect of oil prices becomes significant.

The second line of research focuses on the identification of optimal monetary policies in response to oil shocks. Brown, Oppedahl and Yucel (1995) in their study on how oil prices transmit through various channels of the US economy to influence inflation suggest that monetary policy generally accommodated the inflationary pressure of oil price shocks. Hamilton (2003) investigated the role of monetary policy in eliminating recessionary consequences of an oil shock and concludes that the potential of monetary policy to avert the contractionary consequences of an oil price shock is little or not as great as suggested by the analysis of Bernanke, Gertler, and Watson (1997). A study by Bouakez, et al (2008), using a Dynamic Stochastic General Equilibrium (DSGE), analyzes how high oil prices would lead to an increase in inflation by a much greater magnitude under managed than under a fixed exchange rate regime. Furthermore, De Fiore, et al. (2006) looked at simple policy rules and found that oil price shocks brought about a trade-off between inflation and output stabilization and, thus, monetary policy partially accommodated oil-price increase.

This present paper differs from most of the previous empirical studies carried out because focus has mainly been on oil-importing economies, particularly the developed economies. Few studies exist on the effect of oil price shocks on key macroeconomic variables for an oil-exporting country as Nigeria. This study intends to fill this gap as it centers on the pass-through of oil prices into inflation.

Oil price shocks exert influence on macroeconomic activity through various channels. Such influences may imply a symmetric effect; however, the effect can also be asymmetric. Guo and Kliesen (2005) in their paper explicitly distinguished between two channels through which changes in oil prices affects aggregate economic activity; the change in the dollar price of crude oil (relative price change) and; the increase in uncertainty about future oil prices; noting that the former channel implies a symmetric effect of oil shocks, while the latter implies an asymmetric effect. Symmetry with respect to oil price changes implies that the responsiveness of the economic variable to a negative oil price shock will be the exact mirror image of the response to a positive oil price shock of the same magnitude; while asymmetry simply implies that the response of an economic variable to a positive oil price shock will not be proportional to the opposite response of the variable to a negative oil price shock of the same magnitude. Chuku, et al (2010) put forth that the asymmetric responses of macroeconomic aggregates to unanticipated oil price decreases and increases can be explained through three kinds of effect: (1) the income effect, (2) the uncertainty effect and (3) the reallocation effect. They go further to state that asymmetry arises because these three effects act in a reinforcing way to amplify the response of macroeconomic aggregates to positive oil price shocks, but reduce the corresponding response to negative oil prices shocks. Thus, making it possible to explain why economies experience higher recessions in response to positive oil price shocks, and smaller expansions in response to negative oil price shocks of the same magnitude.

A number of studies have focused on the empirical investigation of the theoretical mechanism and channels through which oil-price change may retard economic activity (see Brown and Yucel, 2002; Jones et al., 2004; Tang et al., 2010). These channels include the supply-side effect, wealth transfer effect, inflation effect, real balance effect, sector adjustment effect and the unexpected effect. They are discussed briefly below making use of Figure 1 which depicts the channels of transmission from oil price shocks to macroeconomic variables.

There is the *classical supply side channel* according to which oil price increase leads to a reduction in output since the price increases signal the reduced availability of basic input to production. As a result, growth rate and productivity decline. Oil price shocks can increase the marginal cost of production in many industries reducing the production. After an oil shock, since the investment determines the potential output capacity in the long run, higher input prices reduce the investments, thus, output decreases and unemployment increases (Brown and Yücel, 2002).

The second mechanism is the *wealth transfer effect* which emphasizes the shift in *purchasing power (income)* from oil importing nations to oil exporting nations (Fried and Schultze, 1975; Dohner, 1981). This shift leads to a reduction in the consumer demand for oil importing nations and increases consumer demand in oil exporting nations. In turn, the global demand for goods produced in oil importing nations is reduced and the global supply of savings is increased. Consequently, increasing supply of savings causes real interest rates to decrease. Diminishing world interest rate should stimulate investment that balances the reduction in consumption and leaves aggregate demand unchanged in the oil importing countries. If prices are downward sticky, the reduction in demand for goods produced in oil importing countries will further reduce the GDP growth. If the price level cannot fall, consumption spending will fall more than increases in investments leading to a fall of aggregate demand and further slowing economic growth (Brown and Yücel, 2002).

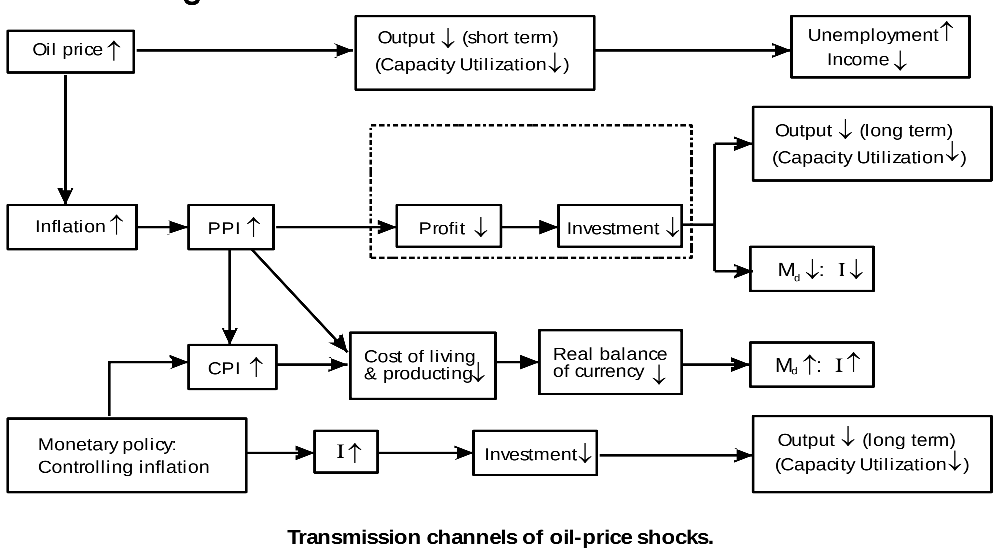
Another transmission channel which establishes a relationship between domestic inflation and oil prices is the *inflation effect.* Oil price shocks are found to create inflationary pressures in an economy. Literature on the subject has indicated that reduced output and inflation are the most likely twin effects of oil price shocks. An oil price shock constitutes a cost for domestic production (i.e. supply-side channel) resulting in an upward pressure on labour costs and prices. This can be considered as a price shocks too. According to Tang, et al (2010), when the observed inflation is caused by the oil-price increased cost shock, a contractionary monetary policy can deteriorate the long-term output by increase in interest rate and decrease in investment.

The real balance effect which elucidates the influence oil price shocks would have on money demand in an economy could occur under two scenarios. On the one hand, the variation in consumers' expectation with respect to the short-term and long-term effects of an increase in oil prices will result in borrowing or dissaving in order to align consumption. Consequently, interest rates and inflation rise and the demand for real cash balances reduce. On the other hand, working through the price-monetary transmission mechanism, oil price shocks can reduce investment due to the reduction in producers profit and equally reduces money demand (see Chuku, et al, 2010). When monetary authorities fail to increase money supply to meet growing money demand, interest rate will rise, leading to a reduction in growth rate.

The fifth transmission channel is the sector adjustment effect which works via effects of oil shocks on economic sectors. Brown and Yucel (2002) argued that possible explanations for asymmetric sectoral adjustments are monetary policy, adjustment costs and petroleum product prices and not the supply-side effect. Following an oil price shock which feeds directly to output, the cost of adjusting to changes in oil prices in each sector of an economy may also retard economic activity. As pointed out by Brown and Yucel (2002) adjustment costs arise due to sectoral imbalances and coordination problems between firms or because the energy-to-output ratio is part of the capital stock. In the case of sectoral imbalances, increasing (decreasing) oil prices would require energy-intensive sectors to contract (expand) and energy-efficient sectors to expand (contract). By implication, asymmetry in oil prices will result in underutilization of resources and rising unemployment.

The uncertainty about oil prices and its impact also influences macroeconomic activity adversely through the reduction in the investment demand of firms and consumers' demand. Uncertainty causes firms and consumers to postpone irreversible investment and consumption decisions, respectively (see Bernanke, 1983; Pindyck, 1991). For example, if the energy-to-output ratio is embedded in the capital stock, the firm must choose the energy-intensity of its production process when purchasing capital. For consumers, the uncertainty effect mainly applies to consumer durables, especially energy-using consumer durables. Uncertainty about future oil prices applies to both downward and upward movement in oil prices. Worthy of note is that as future prices becomes increasingly uncertain, the value of postponing the investment (consumption) decision increases, and the net incentive to invest (consume) decreases thereby dampening long-term prospects of output (Chuku, et al 2010).

Figure 1: Transmission Channels of Oil Price shocks



Source: Adapted from Tang et al. (2010)

II.2 Theoretical Framework

II.2.1 Theoretical Foundations: The Phillips Curve Methodology

The Phillips curve presents a historical inverse relationship between unemployment and inflation rates. It simply states that the lower the unemployment in an economy, the higher the rate of inflation. Generally, the Phillips curve started as an empirical observation in search of a theoretical explanation. Specifically, the Phillips curve tried to determine whether the inflation-unemployment link was causal or simply correlational. However, Milton Friedman tried in providing explanations to the regularity in the short-term Phillips curve. He posits that there is a short-term correlation between inflation shocks and employment. When inflationary surprise occurs, workers are made to accept lower pay since the fall in real wages is not seen instantaneously. On the other hand, firms hire the workers because they view the inflation as allowing higher profits for given nominal wages.

II.2.2 Oil Price-Inflation Relationship

Inflationary pressures manifest themselves when the overall demand for goods and services grow faster than the supply, causing a decrease in the amount of unused productive resources. Economists have measured economic slack in various ways. Perhaps, the most common measure is the unemployment rate, which measures unused resources in the labor market. Another measure of slack is the real output gap, the estimated difference between actual output and the economy's potential output. The main difficulty with the output gap measures is that they depend on assumptions about the behavior of potential output, an area of macroeconomics where there is little consensus. Monetary policy is also a candidate explanation for any sustained change in the inflation process. Indeed, in the 1970s, many economists argued that relative price changes, even as large as the OPEC oil shocks, would only be inflationary if accommodated by monetary policy.

We utilize a short-run Phillips curve to describe the tradeoff between inflation (the log change in the All Items CPI-U) and a measure of economic slack, along with other variables that affect the price level by changing the cost of producing goods and services. Crude oil prices are included in the Phillips curve to test the proposition that petroleum prices are not only important in production, petroleum is used to produce and transport a wide range of goods and services, but also as a harbinger of inflationary pressure which may exceed its importance as a productive input. In addition, we also include interest rates, domestic maximum lending rate as a measure of monetary policy. Our assumption that monetary policy works strictly through interest rates is conservative, as it ignores other policy channels. We relax this assumption by including the effective exchange rate as an exogenous variable in selected models (LeBlanc and Chinn, 2004).

III. Methodology

Anecdotal evidence from the literature reveal that the autoregressive distributed lag model (ARDL) is one of the major workhorses in dynamic single-equation regressions. The ARDL approach yields consistent estimates of the long-run coefficients that are asymptotically normal, irrespective of whether the underlying regressors are I(1) or I(0), (Pesaran and Shin, 1995). One particularly attractive reparameterization to researchers is the error-correction model (EC);

which uses have increased over time (Engle and Granger (1987)). By determining the order of integration of the variables and forming a linear combination of the nonstationary data, all variables are transformed equivalently into an EC model with stationary series only. This methodology, in addition to other benefits already mentioned, allows researchers to explore correct dynamic structure. It allows for inferences on long-run estimates which are not possible under alternative cointegration procedures. Finally, ARDL model can accommodate greater number of variables in comparison to other Vector Autoregressive (VAR) models (Pesaran and Shin, 1995).

First, the variables used are tested for unit root. This testing is necessary to avoid the possibility of spurious regression as Ouattara (2004) reports that bounds test is based on the assumption that the variables are I(0) or I(1). Therefore, in the presence of I(2) variables, the computed F-statistics provided by Pesaran et al. (1995) becomes invalid. Hence, the implementation of unit root tests in an ARDL procedure is still necessary in order to ensure that none of the variables is integrated of order 2 or above. If the variables are found to be I(0) or I(1) the ARDL approach to cointegration is applied and it consists of three stages. In the first step, the existence of a long-run relationship between the variables is established by testing for the significance of lagged variables in an error correction mechanism regression. Then the first lag of the levels of each variable are added to the equation to create the error correction mechanism equation and a variable addition test is performed by computing an F-test on the significance of all the lagged variables. The second stage is to estimate the ARDL form of equation where the optimal lag length is chosen according to one of the standard criteria such as the Akaike Information or Schwartz Bayesian. The third stage entails the estimation of the error correction equation using the differences of the variables and the lagged long-run solution, and determines the speed of adjustment to equilibrium. Further, stability of short-run and long-run coefficients is examined by employing cumulative CUSUMSQ statistics which are updated recursively and plotted against the break points. If the plots of CUSUM and CUSUMSQ statistics stay within the critical bonds of 5% level of significance, the null hypothesis that all coefficients in the given regression are stable cannot be rejected.

III.1 Sources of Data, Scope and Characteristics of Variables

The empirical investigation of oil price pass-through into inflation in Nigeria is based on a 21-year quarterly time series data (1990Q_1 to 2010Q_4), i.e 84 observations compiled from secondary sources. The sources are Central Bank of Nigeria (CBN), Statistical Bulletin, Volume 20, December 2009, CBN Annual

Reports and Statements of Accounts (various issues), Statistical News of the National Bureau of Statistics (March 15, 2011) and OPEC website.

The macroeconomic variables considered include consumer price index (CPI), real gross domestic product (RGDP), denoted by Y, crude oil price of Nigeria's Bonny Light (COP), nominal exchange rate (NEXR), broad money supply (M2), domestic maximum lending rate (MLR) and output gap$(\bar{Y})$. The gap is the Hodrick-Prescot filtered trend of real output. The quarterly series adopted in this paper makes it different from some of the papers on oil price shock and macroeconomic activities in Nigeria as well as oil price distortions and their short and long-run impacts on the Nigerian economy. These papers utilized annual series, which hinders the possibilities of deriving in depth insight into the impact of the oil shocks.

III.2 Models Specification and Estimation

Following Kiptui (2009), with some modifications, we estimate the effect of oil prices using the autoregressive distributed lag (ARDL). Equation (1) below is to be estimated.

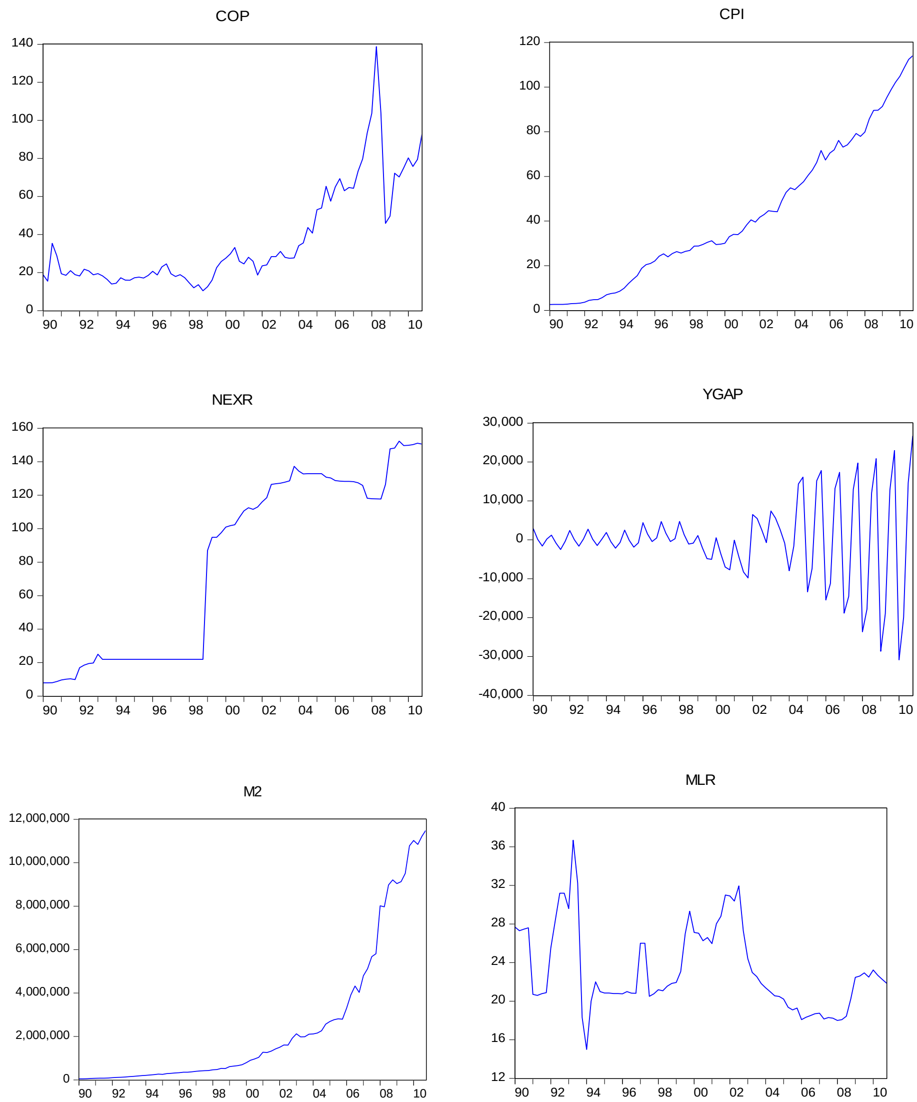
$$\Delta LCPI_t = \alpha + \sum_{i=1}^{i=m} \beta_i \Delta LCPI_{t-i} + \sum_{i=0}^{i=m} \theta_i \Delta LCOP_{t-i} + \sum_{i=0}^{i=m} \lambda_i \Delta LNEXR_{t-i} + \sum_{i=0}^{i=m} \sigma_i \Delta LM2_{t-i} + \sum_{i=0}^{i=m} \partial_i \Delta MLR_{t-i} +$$
$$\sum_{i=0}^{i=m} \varphi_i \Delta (Y_{t-i} - \bar{Y}_{t-i}) + \chi_i LCPI_{t-i} + \delta_i LCOP_{t-i} + \eta_i LNEXR_{t-i}. + \omega_i LM2_{t-i}. + \vartheta_i MLR_{t-i}$$
$$+ \kappa_i (Y_t - \bar{Y}_t) + \infty_i CPI_t + \wp_i COP_t + \tau_i NEXR_t. + \xi_i M2_t + \gamma_i MLR_t + \mu_t \qquad (1)$$

where $LCPI$ is the logarithm of the CPI index, Y is real GDP, $\bar{Y}$ is the Hodrick-Prescot filtered trend of real output, $LM2$ is the logarithm of the broad money supply (M2), mlr is the domestic maximum lending rate and $LNEXR$ is the logarithm of the nominal exchange rate, Δ is the first difference operator. The *a-priori* signs for all the variables considered are positive.

IV. Empirical Findings and Analysis

The empirical investigation begins with the plots of the variables used in the paper in order to have preliminary insights into the behavior and characteristics of the series. They are displayed as follows:

Figure 2: Graphical Representation of Variables



The next step undertaken was to investigate the summary statistics and correlation matrix of the variables. This is followed by the unit root test which is conducted to examine the order of integration of each of the variables in the model. This is to guard against the problem of spurious correlation/regression

IV.1 Results of Summary Statistics, Correlation Matrix and Unit Root Test

IV.1.1 Summary Statistics

The summary statistics of consumer price index, crude oil price, exchange rate, output gap, domestic lending rate and broad money supply are as shown in Table 1 below. The mean for the consumer price index, crude oil price, exchange rate, output gap, domestic lending rate and broad money supply was 42.27, 37.17, 79.44, 9.30E-09, 23.19 and 2,496056, respectively. The standard deviation indicates that the variables exhibit significant variation in terms of magnitude, suggesting that estimation at levels may introduce some bias in the results. The probability of Jarque-Bera for the variables, except for output gap is significant; hence we fail to accept the null hypothesis that the series are normally distributed.

Table 1: Summary Statistics of the Variables

	CPI	COP	NEXR	$\bar{Y}$	MLR	M2
Mean	42.26646	37.17226	79.44212	9.30E-09	23.18917	2496056.
Median	33.45555	25.87000	102.0953	-29.53364	21.83500	933448.9
Maximum	114.2000	138.7400	152.3017	26731.78	36.69000	11525530
Minimum	2.577855	10.39000	7.938800	-30865.80	15.00000	48950.50
Std. Dev.	31.81256	26.85146	54.34379	10721.61	4.317034	3311739.
Skewness	0.569379	1.440056	-0.152938	-0.247070	0.805916	1.549171
Kurtosis	2.258558	4.567507	1.218774	3.902243	2.990269	4.102302
Jarque-Bera	6.462778	37.63242	11.43214	3.703759	9.093347	37.85178
Probability	0.039503	0.000000	0.003293	0.156942	0.010602	0.000000
Sum	3550.383	3122.470	6673.138	7.81E-07	1947.890	2.10E+08
Sum Sq. Dev.	83999.22	59843.05	245119.6	9.54E+09	1546.853	9.10E+14
Observations	84	84	84	84	84	84

IV.1.2 Correlation Matrix

The correlation matrix of the variables is shown in table 2 below. The results indicate positive relationship between consumer price index and crude oil price, exchange rate, output gap and broad money supply. An inverse relationship was observed between consumer price index and domestic lending rate.

Table 2: Correlation Matrix

	CPI	COP	NEXR	$\bar{Y}$	MLR	M2
CPI	1	0.8477	0.8726	0.0178	-0.3733	0.9230
COP	0.8477	1	0.6686	-0.0361	-0.4074	0.8522
NEXR	0.8726	0.6686	1	-0.0195	-0.1484	0.7049
YGAP	0.0178	-0.0361	-0.0195	1	-0.0544	-0.0109
MLR	-0.3733	-0.4074	-0.1484	-0.0544	1	-0.3037
M2	0.9230	0.8522	0.7049	-0.0109	-0.3037	1

IV.1.3 Unit Root Test Results

To examine the existence of stochastic non-stationarity in the series, the paper establishes the order of integration of individual time series through the unit root tests. The tests of the stationarity of the variables adopted were the Augmented Dickey Fuller (ADF) and Phillips-Perron (PP), which are stated in generic form as follows:

IV.1.3.1 Augmented Dickey Fuller (ADF) Specification for Unit Root

The ADF involves the estimation of one of the following three equations respectively, (Seddighi, et al, 2000):

$$\Delta X_t = \beta X_{t-1} + \sum_{j=1}^{p} \delta_j \Delta X_{t-j} + \varepsilon_t \qquad (2)$$

$$\Delta X_t = \alpha_0 + \beta X_{t-1} + \sum_{j=1}^{p} \delta_j \Delta X_{t-j} + \varepsilon_t \qquad (3)$$

$$\Delta X_t = \alpha_0 + \alpha_1 t + \beta X_{t-1} + \sum_{j=1}^{p} \delta_j \Delta X_{t-j} + \varepsilon_t \qquad (4)$$

The additional lagged terms are included to ensure that the errors are uncorrelated. The maximum lag length chosen begins with 4 lags and proceeds down to the appropriate lag by examining the Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC). The null hypothesis is that the variable X_t is a non-stationary series (H_0: $\beta = 0$) and is rejected when β is significantly negative (H_a: $\beta<0$). If the calculated ADF statistic is higher than the McKinnon's critical values, then the null hypothesis (H_0) is not rejected and the series is non-stationary or not integrated of order zero I(0). Alternatively, rejection of the null hypothesis implies stationarity. Failure to reject the null hypothesis leads to conducting the test on the difference of the series, so further differencing is conducted until stationarity is reached and the null hypothesis is rejected.

IV.1.3.2 Phillips-Perron (PP) Specification for Unit Root

Phillips and Perron (1988) use a nonparametric method to correct for serial correlation in the disturbances. The test is based on the estimate of the long run variance of the residuals. Their modification of the Dickey and Fuller Γ test is called the Z(Γ) test. The critical values for ΓΓ and Z(ΓΓ) are the same if the residuals are generated by an independent and identical process. Although the Phillips and Perron tests and the Dickey and Fuller tests provide identical results, the power of the (Augmented) Dickey and Fuller tests is more than the Phillips and Perron tests in the presence of negative moving average components.

The variables tested are: cop, cpi, nexr ygap, mlr and lm2. They have been transformed by deriving their natural logarithm. The results indicate that some of the variables - lcpi, mlr and ygap - are stationary at levels. lcop, lm2 and lnexr were found to be non-stationary at levels. This implies that the null hypothesis of non-stationarity for the variables is not rejected. However, they became stationary after first difference, which implies that they are I(1) series. The unit root tests results are presented in table (3) below:

Table 3: ADF and PP Unit Root Tests

Variable	ADF			Phillips-Perron		Remarks
	Level	1st Difference	Remarks	Level	1st Difference	
LCOP	-2.7379	-9.2362***	I(1)	-2.6193	-9.8602***	I(1)
LCPI	-3.6769**		I(0)	-2.9337**		I(0)
LNEXR	-1.6458	-8.7578***	I(1)	-1.6445	-8.7578***	I(1)
Ygap	-2.5347**		I(0)	-9.2268***		I(0)
MLR	-3.2786*		I(0)	-3.1901*		I(0)
LM2	-2.8091	-10.7623***	I(1)	-2.7017	-10.5633***	I(0)

Note: ***, ** and * indicates that the variables are significant at 1 per cent, 5 per cent and 10 per cent levels, respectively.

IV.1.4 Lag Order Selection Criteria

The table below shows the lag length which was determined by various lag order selection criteria by estimating a VAR model. Six lags were found optimal as indicated by the LR test statistic, Final Prediction Error (FPE) and Akaike Information Criteria (AIC). On the other hand, Shwarz Information Criterion and Hannan-Quinn Information Criterion found two and four lags optimal, respectively.

Table 4: Lag order selection criteria

VAR Lag Order Selection Criteria
Endogenous variables: LCOP LCPI LNEXR YGAP
Included observations: 77

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1015.868	NA	3754902.	26.49008	26.61183	26.53878
1	-633.2167	715.6075	274.7578	16.96667	17.57545	17.21017
2	-581.0546	92.13033	107.7893	16.02739	17.12320*	16.46571
3	-567.9226	21.82981	117.1477	16.10189	17.68472	16.73500
4	-524.9474	66.97437	59.10351	15.40123	17.47109	16.22916*
5	-502.9716	31.96483	51.99524	15.24602	17.80289	16.26874
6	-481.0889	29.55580*	46.48941*	15.09322*	18.13712	16.31075
7	-466.8305	17.77669	51.56859	15.13846	18.66938	16.55080

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

Mordi (2007) notes that typically for a given p_j, the values of these criteria will be ranked as $AIC(p_j) \leq HQ(p_j) \leq SC(p_j)$. That is, the Schwarz criterion penalizes the most the inclusion of extra lags, while Akaike has the lowest penalty. For these reasons, all criteria will not necessarily suggest the same lag length. In fact, practical experience shows that the Schwarz criterion will often choose too small an order for the VAR system. We therefore estimate an ARDL model with two lags of each variable and sequentially removed insignificant lags while observing the Akaike Information and Schwarz Information criteria for model improvement.

From Kiptui (2009), the short-run pass-through will be given by the estimated coefficient (θ) while the long-run or full pass-through from an oil price shock to inflation is derived as follows:

Pass-through

$$(\psi) = \frac{\sum_{i=0}^{i=n} \theta_i}{1 - \sum_{i=1}^{i=n} \beta_i} \qquad (5)$$

IV.2 Empirical Results

The empirical estimation results contained in table 5 below, showed significant results. Crude oil price, nominal exchange rate lagged two quarters and inflation lagged one quarter were found to have significant effects on inflation at 1 per cent significant level. The domestic maximum lending rate and broad money supply lagged by one period are significant at 5 per cent. The signs on the coefficients of the variables are positive as expected suggesting that inflation increases following a rise in crude oil price in the international oil market, increased aggregate demand and a depreciation of the currency.

Table 5: Empirical Results

Dependent Variable: D(LOG(CPI))
Method: Least Squares
Sample (adjusted): 1990:4 2010:4
Included observations: 81 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.202141	0.050629	3.992587	0.0002
D(LOG(CPI(-1)))	0.329813	0.095741	3.444852	0.0009
D(LOG(COP))	0.036998	0.028594	2.729406	0.0062
D(LOG(NEXR(-2)))	0.111998	0.031017	3.610817	0.0005
D(MLR)	0.005558	0.001961	2.834825	0.0059
LOG(M2(-1))	0.012125	0.003537	3.428611	0.0010

R-squared	0.389795	Mean dependent var	0.046484
Adjusted R-squared	0.349114	S.D. dependent var	0.054548
S.E. of regression	0.044008	Akaike info criterion	3.337695
Sum squared resid	0.145254	Schwarz criterion	3.160329
Log likelihood	141.1766	Hannan-Quinn criter.	3.266533
F-statistic	9.581888	Durbin-Watson stat	2.027545
Prob(F-statistic)	0.000000		

From the results, the estimated short-run pass-through ((θ) is 0.04, which is the coefficient for COP, β is the autoregressive coefficient of the consumer price index which is 0.33 and the long-run pass-through (ψ) from an oil price shock to inflation is computed using equation (5) as 0.06. Hence, the pass-through of oil price increases to inflation is *0.04 in the short-run* and in *the long-run pass-through 0.06*. It suggests that a 10.0 per cent increase in crude oil price leads to 0.004 per cent increase in inflation in the short run and 0.006 per cent in the long-run. From literature, Duma (2008), LeBlanc and Chinn (2004), and Kiptui (2009) find low and incomplete pass-through due to a combination of factors such as high component of food in the CPI basket, administered prices, as well as low persistence and volatility of the exchange rate.

This result may not be surprising given that oil price shocks affect Nigeria symbiotically. Nigeria exports crude petroleum and imports refined petroleum products. In that regard, to balance the impact over the business cycle, there must be a stabilization policy – Sovereign Wealth Investment Authority (SWIA) - as well as a mechanism that will encourage savings in a boom time and the full cost recovery on the pump price of petroleum products.

In addition, the exchange rate pass-through to inflation is 0.11 in the short-run and 0.17 in the long-run. This also represents another case of incomplete pass-through but much higher compared to the oil price pass-through to inflation.

There is anecdotal evidence that suggests a relationship between the exchange rate and oil prices. In periods of huge disbursements from the Federation Account, the resulting depreciation in exchange rate push prices up thus exerting pressure on the effective implementation of monetary policy by the central bank. In addition, there is the plausibility of the occurrence of imported inflation. These effects can only be separated through further study.

The result of the diagnostics tests is indicated below:

Table 6: Result of Diagnostic Tests

Diagnostics	**Probability (*p*) values**
Jarque-Bera Normality	0.5059
Breush-Pagan-Godfrey Heteroskedasticity	0.2637

From the result of the diagnostic tests, the Jarque-Bera statistic is not significant indicating that the residuals of the model are normally distributed. In addition, the heteroskedasticity result shows that there is no evidence of the presence of heteroskedasticity, since the *p-value* is in excess of 0.05.

The empirical results also pass the stability tests (CUSUM and CUSUM Squares tests), as shown in figures 3 and 4 below:

Figure 3: Diagnostic tests - CUSUM

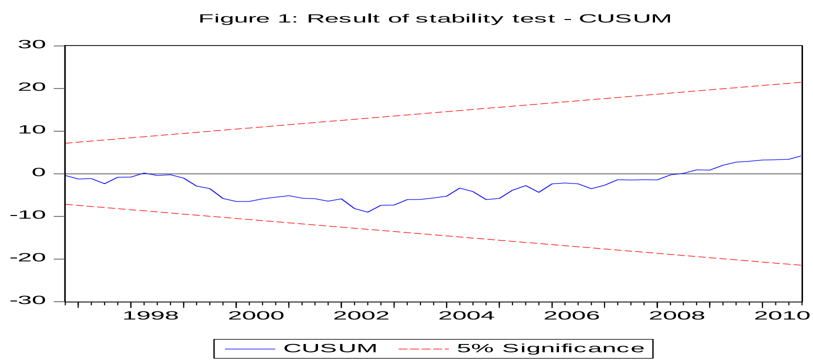
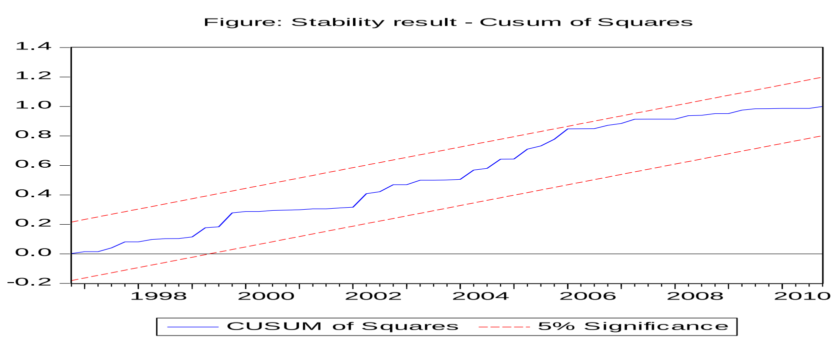


Figure 4: Diagnostic tests – CUSUM of Squares



According to Brooks (2008; pp. 187-188), "the CUSUM statistic is based on a normalized (i.e scaled) version of the cumulative sums of the residuals. The null hypothesis of perfect parameter stability, the CUSUM statistic is zero, however, many residuals are included in the sum (because the expected value of a disturbance is always zero). The standard error bands is usually plotted around zero and any statistic lying outside the bands is taken as evidence of parameter instability. Similarly, the CUSUMSQ test is based on a normalized version of the cumulative sums of squared residuals. Under its null hypothesis of parameter stability, the CUSUMSQ statistic will start at zero and end the sample with a value of 1. In the same vein, a set of ± 2 standard error bands is usually plotted around zero and any statistic lying outside these is taken as evidence of instability". Since the line is well within the confidence bands, the conclusion is that the null hypothesis of stability is not rejected.

V. Conclusion

This paper attempts to estimate the oil price pass-through to inflation in Nigeria. It is shown that oil price is positively correlated with inflation. The measure of oil price pass-through to inflation is found to be 0.04 in the short-run and 0.06 in the long-run much lower when compared with the exchange rate pass-through of 0.11 in the short-run and 0.17 in the long-run. The paper concludes that oil price pass-through in Nigeria is low and incomplete, which is consistent with the findings in other studies.

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Appendix

FIGURE 1: RELATIONSHIP BETWEEN PRICE OF OIL AND INFLATION

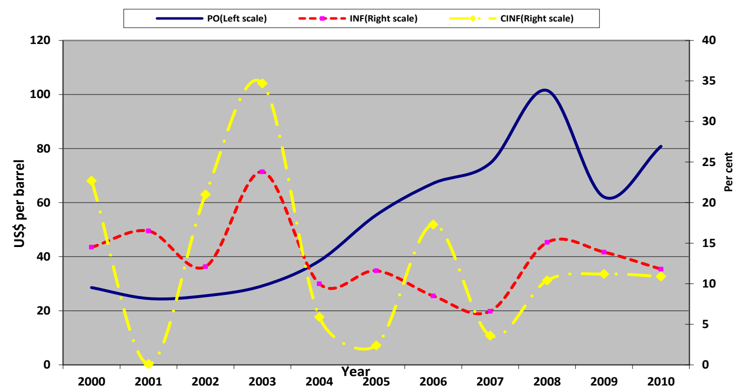

FIGURE 2: RELATIONSHIP BETWEEN PRICE OF OIL AND EXCHANGE RATE