East African Scholars Journal of Economics, Business and Management
Abbreviated Key Title: East African Scholars J Econ Bus Manag
ISSN 2617-4464 (Print) | ISSN 2617-7269 (Online)
Published By East African Scholars Publisher, Kenya

Volume-4 | Issue-11 | Dec-2021 | DOI: 10.36349/easjebm.2021.v04i11.004

OPEN ACCESS

Original Research Article

Oil Price Shocks and Industrial Output in Nigeria; is The Relationship Linear?

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Article History
Received: 03.11.2021
Accepted: 08.12.2021
Published: 25.12.2021

Journal homepage:
https://www.easpublisher.com

Quick Response Code

Abstract: Industrialization being an engine of growth in modern economies and the primary roles energy plays in driving industrialization, stability of oil prices has become a crucial factor with spatial and temporally implications for the performance of the Nigerian industrial subsector. In this regard, this study examined the symmetric and asymmetric effects (if any) of the oil price dynamic on the Nigerian industrial subsector using ARDL and NARDL frame works based on quarterly time series data spanning $1970Q_1$ to $2018Q_4$. The result of the short-run linear ARDL model reveals that oil price stimulates marginally the performance of the building and construction industry as well as aggregated industrial output but unfortunately dampened the performance of the manufacturing subsector. Similar to the short-run result, the long-run non-linear shows that oil price shocks (increase and decrease) have mixed and variegated effects on the industrial subsector and its constituents as confirmed by the probability values of the Wald's test. The results show that increase in the price of oil dampened aggregate industrial output and manufacturing index with marginal increase in building and construction output. Conversely, a decrease in oil price stimulates industrial manufacturing, building and construction indexes in the long-run though short-lived compare to the negative effects that propagate for a longer period. In light of the empirical findings and the asymmetric nature of oil price shocks on Nigerian industrial subsector, Nigerian government and the industrialists should formulate appropriate trade policy and develop sound industrial policy management mechanism to effectively mitigate the negative effects of oil price shocks on Nigerian industrial subsector. These include inward looking industrial policy, establishment of light industries, promotion of small and medium scales enterprise, Small and Medium Industry Equity Investment Scheme (SMIEIS), National Integrated Industrial Development (NIID), Industrial Park Development strategy (IPDs) and proper funding of Bank of Industry (BOI) during period of oil boom and consequently smoothen Nigerian industrial performance at all times irrespective of the magnitude of oil price variation.

Keywords: Oil price shocks, industrialization, ARDL, NARDL, asymmetric symmetric.

JEL CLASSIFICATION: C11, O14, P22, Q41, Z31.

1.1 INTRODUCTION

Oil price shocks are unexpected and unpredictable changes in global oil prices, caused by exogenous factors which may have an impact on endogenously determined economic variable. In the recent past decades, the global energy market has witnessed several distortions in oil prices. In economics, a number of transmission channels exist through which oil price affects output. An increase in oil price will lead to higher input costs and consequently increase the cost of production of goods and services. The production volume may thus be affected as firms may find it difficult in the short-run to reallocate resources in order to produce the same several of goods and services (Balciar *et al.*, 2017).

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The import-dependent nature of the Nigerian economy makes her be at the mercy of the developed countries, especially her trading partners, thereby making her highly susceptible to external shocks because the price of Nigeria's primary export product (crude oil) is quoted in US dollar rather than in Naira, there would be high demand for the dollar at the expense of the Naira thereby leading to appreciation of dollar at the expense of Naira with adverse effect on Nigerian economy including the industrial subsector (Ogunjimi, 2020).

Industrialization refers to structural changes in which industrial production dominates primary and agricultural production. A nation is said to be industrialized when an agrarian economy dominated by the use of elementary tools gives away to one in which machines and power tools are widely developed within a structural automated factory environment. Industrialization involves application of scientific methods to solve problems, mechanization, factory based mass production and the contribution of industry to GDP is more than 50% percent (Mailafia, 2016).

Recognizing the significance of oil price fluctuations to the Nigerian economy, several authors have investigated the oil price-macroeconomy in Nigeria (Ayadi, 2005: Akpan 2009: Aliyu, 2009: Chuku, *et al*. 2010: Olomola and Adejumo and Olubusoye, *et al*., 2015) which continues to dominate and inspire the minds of policy makers and academicians. Specially, the findings of Olomola and Adejumo, (2006) Contradict evidences from previous and recent related studies on the effect of oil price shocks on macroeconomic variables in Nigeria. They suggest that oil price shocks significantly influenced real exchange rate but not output and inflation in Nigeria. Iwayami and Fowowe (2011) confirmed this from their analysis by concluding that oil price shocks do not have a major impact on most macroeconomic variables in Nigeria.

Given the plethora of studies on the relationship between oil price shock and macroeconomic variables in Nigeria, the literature is yet to provide detailed and conclusive evidence as to how oil price shocks affect the industrial sector and its subsectors in Nigeria, given the idiosyncrasies inherent in the Nigerian economy. This study is a modest contribution to the literature and evidence on the effects of oil on price instability on industrial sector for an oil exporting (and importing) developing economy. It is different from previous efforts at decoupling the impact of oil price shocks on macroeconomic variables because the study will clearly differentiate between linear and asymmetric effects of oil price on Nigerian industrial subsector. A disaggregated specification and estimation of the industrial subsector will be undertaken. For specifics, short and long run impacts will be examined simultaneously amidst higher frequency data mode with longer time duration of $1970Q_1$ to $2018Q_4$. To this end, this study adopts the Autoregressive Distributed Lag (ARDL) and Non-linear Auto Regression Distributed Lag (NARDL) Frameworks to investigate the symmetric and asymmetric relationship (if any) between oil price movement on Nigerian industrial subsector.

The rest of this paper is structured as follows: section 2 focuses on the review of related literature, while stylized fact about the nexus between oil price movements and industrial output is the main thrust of section 3. Section 4 contains theoretical frameworks and model specification. The results are brought forth and discussed in section 5. Section 6 offers concluding remarks and recommendations.

2.0: REVIEW OF RELATED LITERATURE

A number of studies have investigated the impact of oil price shocks on real macroeconomic variables following the first oil price shock of 1970 and subsequent recessions occasioned by oil price shocks (Darby, 1982: Rasche and Tatom, 1981, Hamitton, 1983). Most of these studies focused on the short-run relationship between oil price shocks and the macro-economy and seeking appropriate policy reactions to deal with them.

Oil Price volatility is a recurrent decimal in global oil market and these shocks have raised concerned for policymakers and the academics on the potential effect of oil price shocks on a major macroeconomic variable in open economies and the industrial subsector. As one of the indicators of macroeconomic fragility, the response of individual subsector is another channel through which shocks in oil price have the potential to affect the overall economy.

Industrial response implies increase in industrial process. It involves the introduction and expansion of industries in a particular place, region or country (Obioma and Ozughala, 2005).Industrialization is a situation where many industries are established in different part of the country. As industries are established in a country, different types of products are produced. It is process of building up a country capacity to process a large variety of goods, extract raw materials and manufactured semi – finished goods. (Olowookere & Ogebe, 2019).

Despite the burgeoning body of literature investigating the impact of oil price shocks of the macro economy, a limited literature (theoretical and empirical) has studied the impact of oil shocks on the industrial subsector and those that have attempted, mostly concentrated in industrialized countries. The literature revealed that the impact of oil price shocks on the industrial subsector depends on the country's sectorial composition, institutional structures and level of economic development (Chuku, *et al*. 2010). Schmidst and Zimmermann, 2007 show that oil price shocks have a significant negative impact on industrial output though, unstable for most countries over time. The unstable relationship that had been observed in literature was further stressed by blanchard and Gali (2007).

On the other hand, farzanegan and markward (2009) find a strong positive relationship between oil price change and industrial output growth and observed the Dutch disease syndrome through significant real effective exchange rate appreciation. Conversely, Change and Wong (2003) show that the impacts of oil price stocks had an insignificant adverse affect on Singapore gross domestic output (GDP), inflation and unemployment rate. Berumet and Ceylan (2005) used input Response and variance decomposition analysis, find that the effects of world oil price shocks in GDP of Algeria, Iraq, Jordan, Kuwait, Oman, Qatar, Syria Tunisia and UAE are positive and statistically significant. Zounari – Ghorbel (2009) observed from them linear and non – linear specification that there is no direct impact of oil price shocks on industrial output in Tunisia.

Specially, in Nigeria, Olumola and Adejumo (2006) found that oil price shocks significantly influenced real exchange but not industrial output. The tendency of Dutch disease is high. Ayaili (2005) suggest that oil price changes affect individual output indirectly through it's effect on exchange rates, though statistically insignificant.

Akpan (2009) shows a marginal positive relationship between positive oil price changes and industrial out-put growth. Aliyu (2009) investigated oil price shocks and macroeconomic variables in Nigeria and found evidence of linear and non – linear impacts of oil price shocks on real GDP. Mordi and Adebiyi (2010) also show that the impact of oil price shocks on output and prices is asymmetric in nature with the impact of the price decrease being significantly greater than that of oil price increase.

Olubusoye, *et al.*, (2015) using SVAR model found that oil price shocks do not have significant impact on monetary and real sectors but on fiscal variables (revenue and expenditure. This further confirmed iwayami and fowowe (2011) who finds that oil price shocks do not have a major impact on most macro economy variables in Nigeria. Bacillary *et al*. (2017) using regime – dependent IRFs found that the oil price shocks tend to be more persistent during low growth state compared to high growth state, and the impact on the real subsector is significant due to the asymmetric reaction of monetary authority to mitigate the inflationary effect of oil price shocks at this point in time.

Aye, *et al*. (2014) analyses the impact of oil price uncertainty on manufacturing production in South Africa using a bivariate GARCH–in–Mean–VAR model, and shows oil price uncertainly to have a significant negative impact on manufacturing production. The study also detects that the response of manufacturing production to positive and negative shocks are asymmetric. Herrera, et.al (2011) in their analysis failed to show any asymmetric relationship between oil price and industrial production at the aggregated level, but at disaggregated level, they find strong evidence of a non linear and asymmetric relationship between oil price and output for industries that are energy intensive or produce goods that are energy intensive in use.

Moshiri (2015) find that negative oil price shocks have adverse effects on industrial output, while positive oil price shocks do not have any significant impact on industrial output for less developed countries, on the other hand, oil price shocks (ops - whether positive or negative) do not have any impact on the economics of oil – producing developed countries.

Thus the controversy over the response of industrial output to oil price shocks range on. Our analysis is an improvement on previous studies on the relation between oil price shocks and industrial sector in Nigeria because we do not only examine the linear and symmetric impacts but also focus on the symmetric and non – liner relationship in a disaggregated specification with higher frequency of data (quarterly).

3.0 Industrial Response to Oil Price Shocks: A Review

When Nigeria became politically independent in 1960, agriculture was the main stay of the Economy contributing about 70% of the GDP and about an equal percentage of the working population was employed in the Agricultural sector. In terms of external trade, the sector accounted for about 90 percent of foreign earnings and a substantial share of government revenue (Adedipe, 2004).

In the 1970, there was a dramatic change. Crude oil which was first discovered in commercial quantity in the country in 1956 became the dominant resource in the country. The massive increase of oil revenue as an aftermath of the Middle East war in 1973 created unprecedented, unexpected and unplanned wealth for Nigeria. This period has been tagged the "oil boom" era in Nigerian economic history, (Elijah, *et al.*, 2007).

Since the advent of oil boom, Nigeria has experienced different phases of oil price shocks (increase and decrease) caused primarily by external forces which may have an impact on endogenously determined economic variables including the industrial subsector. Theoretically literature has identified the transmission mechanisms through which oil price shocks affect real economic activity to include supply and demand channels. Under the supply side channel, crude oil is viewed as a basic input of production. An increase in oil price impact-directly on output via increased costs of production through changing domestic capital and labour inputs and reduce capital utilization. Thus, oil price shocks change the marginal cost of production in the industries and hence contracts production (Bashar, *et al*., 2013) on the demand side, a higher oil price, reduced disposable income and thus, decreases consumption.

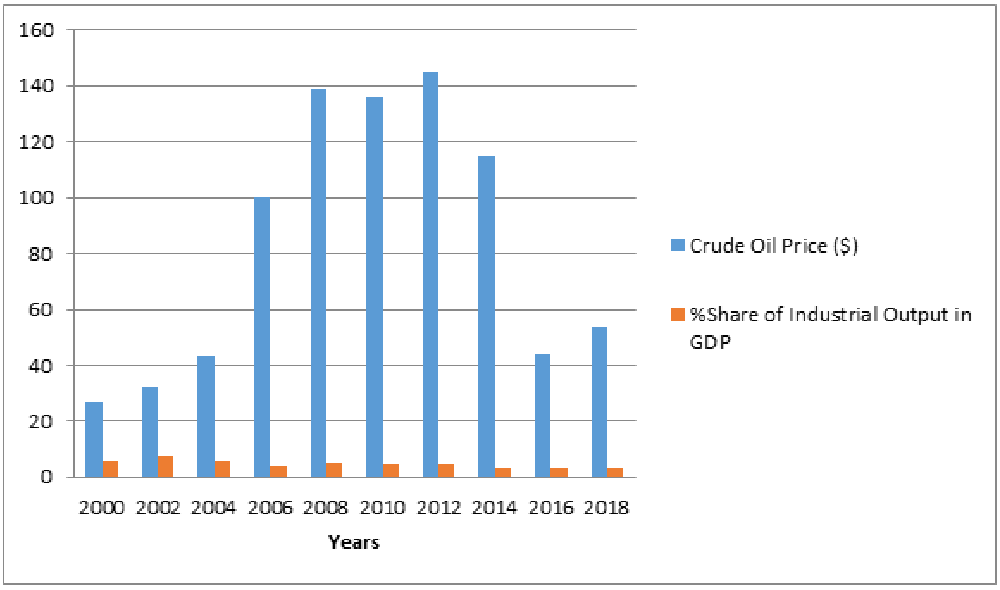


Fig-1: Average International Crude Oil Price and the Contribution of Industrial Subsector to GDP (%Share)

Since the emergence of the oil industry in the late 1960s and its rapid buildup in the 1970s and since then oil became the main revenue source for Nigeria. However, the discovery of oil believed to have contributed in stagnating growth of Nigeria's economy as it has overheated the economy, fuel the twin 'evil of reduced output and inflation'. For instance, during the oil boom era in 1971, the share of industry to GDP stood at 15.33 percent with a marginal increase to 20.24 from in 1980s as light industries came up after the civil war.

In mid 1980s through 1990s, with increased volatility and upshot in crude oil price duty the 1990-1991 Persian Gulf war, the industrial subsector contribution to GDP increased marginally to 21.00 percent resulting from the various industrial policies moving from light to heavy industrial equipment like the establishment of steel industries in Nigeria in 1990s.

With the advent of t he 4th democratic rule in 1999 till date, industrial fortune dwindled significantly as shown in the figure above. The Dutch decreases that accompanied crude oil discovery in commercial quantity in early 1970s heightened in 2000s as Nigeria; mono-product-economy remains susceptible to the movement in international crude oil price. The industrial sector was neglected amidst dwindling infrastructure facility as most multinationals relocated to other countries. Consequently, the contribution of industry to GDP fell drastically from 21 percent in 1990s to 6 percent in 2000.

Furthermore, the price of crude oil oscillates between $50.00 and $150.00 and industrial contribution to GDP dwindled further from 4.65 percent to all time low value of 3.25 in 2018.

Summarily, given the volatile nature of oil price and Nigeria being a mono-product country with high oil dependency rate, the variability of oil price led to policy changes, domestic price distributions and overvalued exchange rates that undermined the traditional and modern industries and the contribution of industry to GDP plummets amidst various industrial policies over the years.

4.0: Theoretical Frame Work and Model Specification

Theoretical Literature has indentified the transmission Mechanisms through which oil price shocks affect real economic activity to include both supply and demand channels. The supply side effects are related to the fact that crude oil is a basic input to production and consequently a positive oil price shock is often considered as an adverse supply shock and is believed to cause a reduced level of output and a high rate of inflation (Bashar. *et al*., 2013). Oil price shocks also entail demand-side effects on consumption and investment. It is expected, that the immediate effect of positive oil price shocks is to increase the cost of production for oil-importing countries like Nigeria. This is likely to decrease output in the industrial subsector. Consequently, a decrease in oil price shocks is expected to stimulate industrial output, due to reduction in prices of imported materials. Does this negative linear relationship hold for Nigeria? if not, what is the nature of the relation between industrial output and oil price shock.

In order to capture the nature of the relationship between oil price shocks and industrial output, this study employs Non-linear Autoregressive Distributed Lags (NARDL), which is built upon Auto-regression Distributed lags model developed by shin *et al*. (2014). NARDL is based on the well known bound testing approach by Pesaran *et al*. (2001) which is a test for Cointegration. The NARDL framework allows us to capture the effects of oil price shocks on specific sector of the Nigerian economy: industrial subsector.

We built our model on the standard neoclassical production function by Solow (1956). The Solow model (eq. 1) is a descriptive model for a closed economy where sectorial output or production (y) is a function of sectorial inputs which are Labour (L), Capital (K) and Productivity (A).

$$Y_t = F(L_t, K_t\ A_t) \qquad 1a$$

The Nigerian economy is far from being closed hence; equation is altered to accommodate the globalized nature of the Nigerian economy and the industrial subsector. Consequently, output from the Nigerian industrial subsector could be simulated as

$$IIP_t = F(EXR_t, INT_t, OIP_t) \qquad 1b$$

$$IIP_t = \beta_0 + \beta_1 EXR_t + \beta_2 INT_t + \beta_3 OIP_t + U_t \qquad 2$$

$$IIP_t = \beta_0 + \beta_1 EXR_t + \beta_2 INT_t + \beta_3 OIP_t^+ + \beta_4 OIP_t^- + U_t \qquad 3$$

The NARDL-ECM version of equation 3 could be written as

$$\Delta IIP_t = \lambda_0 + \lambda_1\ IIP_{t-i} + \lambda_2\ EXR_{t-i} + \lambda_3\ INT_{t-i} + \lambda_4\ OIP_{t-i}^+ + \lambda_5\ OIP_{t-i}^- + \sum_{I=1}^{k} \beta_i\ \Delta IIP_{t-i} + \sum_{I=1}^{k} \beta_2\ \Delta EXR_{t-i} + \sum_{I=1}^{k} \beta_3\ \Delta INT_{t-i} + \sum_{I=1}^{k} \beta_4\ \Delta OIP_{t-i}^+ + \sum_{I=1}^{k} \beta_5\ \Delta OIP_{t-i}^+ + \beta_6 ECM_{t-1} + V_t \qquad 4$$

Equation 4 could be written in compact form as,

$$\Delta \times_t = C_0 + \lambda i X_{t-k} + \sum_{i=1}^{k-1} \beta_i\ \Delta x_{t-i} + e_t \qquad 5$$

Where:

$e_t = (e_{1t}, e_{2t} \dots \dots e_{nt})$ is $P \times 1$ Vector of white noise terms and

$$\sum_{i=1}^{k-1} \beta i\ \Delta x_{t-i}$$

Are the vector autoregressive components in the first differences and error correction components. $X_t = (X_{it}, X_{2t} \dots \dots . . X_{nt})$ include all the stated macroeconomic variables, is a P x I vector and is integrated of at most order one. $C_0 = (C_1, C_2 \dots . . C_n)$ is a constant P x I vector of constants. K is a lag structure. λ_i denotes a P x P matrix that contains the information about the rank and hence the long-term relationship among the variables. The parameter β_i is a P x P matrix that represents short-term adjustments among the variables across P equations at one Lag.

The dependent variable; index of industrial output is further decomposed into its various components of index of manufacturing product (IMP_t), index of Building and Construction product ($IBCP_t$), Index of electricity product (IEP_t) and index of Mining and Quarrying product ($IMQP_t$) While the exogenous variables include Exchange Rate (EXR), Lending Interest Rate (INT) and the Price of Oil (OIL).

The asymmetric cumulative dynamic multiplier effects of a one per cent change in OiP_t^+ and OiP_t^- which will be graphically represented is derived as follows from equation 4.

$$M^+h = \sum_{j=0}^{h} \frac{\partial IIP_{t-J}}{\partial OIP_t^+}, \qquad M^-h = \sum_{j=0}^{h} \frac{\partial IIP_{t-J}}{\partial OIP_t^-}, \qquad h = 0,1,2,3,4 \qquad (6)$$

Note that as $h \to \propto$, $m^+h \to \beta_3$ and $m^-h \to \beta_4$

4.2: Data Measurement and Source

For our empirical analysis, we disaggregated industrial sector: Building and Construction, Electricity, Manufacturing and Mining and Quarrying. The total industrial output was also taking into account. The indexes of the output of these subsectors are applied. The data used for analysis in this study are annual time-series sourced from Central Bank of Nigeria (CBN) Statistical Bulletins, National Bureau of Statistics (NBS) various editions and Energy Information Administration (EID) for the period of 1970 to 2019. Within these periods there have been series of oil price shocks. Persistent oil price shocks such as that of 1978, 1981, 1985-1986, 2008-2009, 2015 and recently 2020 resulting from the COVID-19 Pandemic have extensive effects on macroeconomic variables including the industrial subsector and Nigerians quest for rapid industrialization. Table 1 summarizes the data.

Table-I: Variables Descriptions

Variable	Proxies	Measurement	Source
Index of Industrial Product	Industrial Output Index	Year-on-Year Δ in INDM	CBN
Exchange Rate	Official Exchange Rate	Naira/USD	CBN
Interest Rate	Prime lending Rate	Percent	CBN
Crude oil price	WTl Crude Price	USD/barrel	EIA
Manufacturing Output	Manufacturing output index	Year-on-year Δ in Manufacturing	CBN
Building & Construct Output	Building and Construction Output index	Year-on-year Δ in Building and Construction Index	NBS
Electricity Output	Electricity output Index	Year-on-year Δ in electricity index	CBN
Mining & Quarrying Output	Mining and Quarrying index	Year-on-year Δ in Mining & Quarrying Index	NBS

Source: Authors' Computation

5.0: RESULTS AND DISCUSSION

5.1 Preliminary Analysis

5.1.1 Characteristics of the Variables

Reported in Table 1 are the summary Statistics for the variables.

5.1.1 Descriptive statistics

Table-1: Summary of Descriptive Statistic of the Variables.

	IIP	IMP	IBCP	IEP	IMQP	OIP	EXR	INT
Mean	65.262	35.092	30.062	25.114	21.309	62.090	49.620	14.307
Median	45.362	23.206	26.406	12.689	14.062	45.098	15.724	8.689
Maximum	115.239	75.392	65.323	54.060	45.380	139.306	350.001	30.001
Minimum	14.296	12.539	13.319	6.388	10.324	5.896	0.525	5.425
Std. Dev.	0.896	1.762	0.513	2.345	1.759	0.459	0.575	0.039
Skewness	-0.462	-0.592	0.159	0.052	0.895	0.164	-0.562	-0.597
Kurtosis	1.892	1.395	1.899	1.562	2.562	0.395	1.779	1.929
Jarque-bera	8.262	12.121	10.247	6.561	7.328	5.709	2.109	0.569
Probability	0.005	0.006	0.008	0.012	0.006	0.042	0.329	0.742
Observations	196	196	196	196	196	196	196	196

Source: Authors' Computation

The Skewness values for most of the variables are nearly zero with four having negative signs indicating skewness to the left while the others skewed to the right with positive sign. The kurtosis which measures whether the data are peaked or flat relative to a normal distribution if is with an expected value of 3.0. The results in Table shows that only index of mining and quarrying barely tend towards satisfying this condition. The probability values of the Jarque-bera test for all the variables are low, except for exchange rate and interest rate. This implies the rejection of normal distribution for these variables. Exchange rate and interest rate whose probability values are relatively high indicate normality of their unconditional distribution. From the Table, the mean to median ratio of each variable is within the unit proximity and the standard deviations are relatively low which implies small variability.

5.1.2: Correlation Matrix Result

Table 2 presents the correlation matrix result of the variables employed in this study. Correlation test helps to determine the degree and direction of association between two variables as well helps in detecting multicollinearity among independent variables. Asteriod and Hall (2007) eluded that multicollinearity results when the correlation coefficient is more than the threshold of 0.9 percent.

Table-2: Correlation Matrix Result

	IIP_t	IMP_t	$IBCP_t$	IEP_t	$IMQP_t$	OIP_t	EXR_t	INT_t
IIP_t	1.000							
IMP_t	0.112	1.000						
$IBCP_t$	0.329	0.324	1.000					
IEP_t	0.506	0.691	0.149	1.000				
$IMQP_t$	0.133	0.309	0.040	-0.011	1.000			
OIP_t	-0.021	0.675	0.476	-0.345	-0.035	1.000		
EXR_t	-0.732	-0.589	-0.061	-0.190	0.606	0.324	1.000	
INT_t	-0.394	0.697	0.018	0.344	-0.109	-0.111	0.529	1.000

Source: Authors' Computation

The correlation Matrix Result shows that most of the values are very low except in some few cases like relationship between interest rate, exchange rate and industrial price of oil output, with -0.394, 0.732 and -0.021 respectively. The correlation between the dependent variables themselves is very low. This further reinforced relative absence of multicollinearity. The low coefficients of these variables imply weak relationship between endogenous and exogenous variables. Interestingly, the relationship between oil price shocks and industrial output indicators remained weak and some cases negative as shown in the table 2.

5.1.3: Unit Root Tests

It is pertinent in time series of this nature to carry out unit root tests to avoid a nonsense and spurious regression. A variable is said to be stationary when it has constant mean, variance and covariance. Accordingly, this study adopts the Augmented Dickey-Fuller (ADF) as well as the Phillip Perron (PP) unit root test approach. For a variable to be stationary, its ADF and PP test statistics must exceed the test critical values in absolute term all significance level or its associated probability value must be less than 5 per cent or 0.05.

Table-3: Unit Root Test Results

	Augmented Dickey Fuller (ADF)			**Phillip Person (PP)**		
	Level	**First Difference**	**I(d)**	**Level**	**First Difference**	**I(d)**
IIP	-3.256**	----	I(0)	-3.146**	--	I(0)
IMP	-2.101	-4.219**	I(1)	2.238	-4.767**	I(1)
IBCP	-3.819**	-----	I(0)	-4.070	---	I(0)
IEP	-2.401	-3.815**	I(1)	-2.621	-4.036**	I(1)
IMQP	-2.649	-4.107**	I(1)	-2.740	-4.792**	I(1)
OIP	-1.071	-3.399**	I(1)	-1.086	-4.607**	I(1)
EXR	-1.336	-3.774**	I(1)	-1.793	-3.945**	I(1)
INT	-2.144	-5.399*	I(1)	-1..674	-5.660*	I(1)

Source: Authors' Computation

*Note: * and ** imply statistical significance at 1% and 5% level respectively.*

Table 3 presents the result of the unit root test. The ADF and PP unit root tests results both show that index of Industrial product (I1P) and index of building and construction production (IBCP) are stationary at level I(0), while index of manufacturing product (IMP) index of electricity product (IEP), index of mining and quarrying production (IMQP), oil price, exchange rate and lending interest rates are stationary after first difference I(I).

Having established that none of the variables is integrated at order two I(2), the use of the ARDL and NARDL frame works is justified. Consequence Upon this, the existence of long relationship among the variables is checked for.

5.1.4: Bounds test Cointegration Result

The justification for adopting this approach is that the variables of this study are stationary at levels and at first difference [I(0) and I(I)], a major requirement for the ARDL and NARDL framework. The null hypothesis of no long – run relationship among the variable will be tested. The decision rule for the bounds test is that the null hypothesis should be accepted if the F– statistic is less than the lower bound, rejected when it falls above the upper bound and inconclusive if it falls in between the upper and lower bounds. Result of the Bounds tests are reported in Table 4 below.

Table-4: Bounds Test Cointegration Results.

Linear ARDL Models							
Sig .Level.	**Critical Value**						
	Low (I_0) Bound	**Upper (I_1) Bound**	**Model1 F-value**	**Model 2F-value**	**Model 3 F-value**	**Model 4 F-value**	**Model 5 F-value**
1%	**5.150**	**6.320**	----	---	---	----	--
5%	**3.692**	**4.463**	**5.720**	**4.710**	**4.304**	**1.329**	**0.562**
10%	**3.176**	**4.149**	----	--	---	--	--

Non Linear ARDL Models							
Sig. Level.	**Critical Value**						
	Low (I_0) Bound	**Upper (I_1) Bound**	**Model 6F-value**	**Model 7F-value**	**Model 8 F-value**	**Model 9 F-value**	**Model 10 F-value**
1%	**4.323**	**5.541**	---	---	---	--	--
5%	**3.34**	**4.686**	**5.693**	**4.819**	**4.109**	**1.468**	**0.42**
10%	**2.726**	**3.660**	--	--	--	--	--

Source: Authors Computation

Note: Models 1-5 depict the linear relation between oil price and Index of Industrial Output (IIP), Index of Manufacturing Output (IMP), Index of Building and Construction (IBCP), Index of Electricity Production (IEP) and Index of Mining and Quarrying Production (IMQP) respectively. While, models 6-10 are the Non-linear versions respectively.

The results on the table reveal that the F – statistic of model 4 (1.329) model 5 (0.562), model 9 (1.468) and model 10 (0.426) fall below the lower bound critical value at 5 percent of significance thereby refuting the existence of linear and non – liner cointegration among the variables in the respective models and most often the error term results from such models are not normally distributed. The F – statistic for model 3 (4.304) and model 8 (4.109) fall between the lower and upper bound critical values at 5 percent significance level suggesting that the cointegration test is inconclusive and thus for models and thus, for models 3 and 8 the existence of the long – run relationship among the variable is uncertain. The f – statistic for model1, (5.720), model 2 (4.720), model 6 (5.673) and 7 (4.819) fall above the upper bound critical value at 5 percent significance indicating that there is a long-run relationship among the variables of models, 1, 2, 6 and 7.

Bound test result determines the type of model that would be estimated. The rule states that short-run and long-run ARDL and NARDL models should be estimated for models that show cointegration as well as those whose result is inconclusive, while only the short-run error correction model should be estimated and reported for models that show no evidence of cointegration. Consequently, for this analysis, short-run and long-run ARDL and NARDL models will be estimated for models 1, 2, 3, 6, 7 and 8 while only short run ARDL models will be estimated for models 4, 5, 9 and 10.

5.2: Presentation and Analysis of Empirical Results

5.2.1: Analysis of the Short-run Symmetric and Asymmetric effects of Oil Price Shocks on Industrial Subsector.

Table 5 presents the estimates of the symmetric and asymmetric effects of oil Price shocks on the industrial subsector in Nigeria.

Table-5: Results of Short-run ARDL and NARDL

	ARDL MODELS					NARDL MODELS				
Variables	**Model 1** ΔIIPt	**Model 2 ΔIMPt**	**Model 3 ΔIBCPt**	**Model 4 ΔIEP_t**	**Model 5 ΔIMQPt**	**Model 6 Δ IIPt**	**Model 7 ΔIMPt**	**Model 8 $\Delta IBCP_t$**	**Model 9 ΔIEP_t**	**Model 10 ΔIMQPt**
$\Delta(\mathbf{OIP})$	-0.358	-0.779	0.609	-1.074	-2.360	--	---	---	---	---
$\Delta(\mathbf{OIP^+})$	---	---	---	---	---	0.332	0.759	1.389	0.769	-1.438
$\Delta(\mathbf{OIP^-})$	---	---	---	---	---	-0.444*	-3.609*	-0.639	-0.119*	-2.306
$\Delta(\mathbf{EXR})$	0.621	-093	-1.334	1.306	2.071	0.377	0.440	0.101	0.791	0.339
$\Delta\mathbf{INT}$	-1.375	-1.066	-1.595	0.389	0.839	1.869	0.114	0.550	0.109	0.799
$\mathbf{Ecm(-1)}$	-0.032	-0.053	-0.024	-0.042	-0.041	-0.0010	-0.034	-0.059	-0.024	-0.033
$\mathbf{Adj: R^2}$	0.671	0.592	0.527	0.717	0.676	0.569	0.763	0.521	0.594	0.752

LM (Prob)	1.324 (0.405)	1.394 (0.507)	0.621 (0.134)	1.290 (0.075)	0.321 (0.132)	1.244 (0.063)	2.024 (0.075)	1.329 (0.076)	3.002 (0.074)	3.411 (0.008)
Ramsey Reset test	2.339 (0.260)	1.562 (0.112)	0.060 (0.339)	3.111 (2.462)	1.409 (0.101)	0.062 (0.076)	1.249 (0.399)	1.319 (1.407)	0.414 (0.340)	1.214 (0.624)
Wald Test for short run Asym − metry	—	—	—	—	—	0.032 (0.021)	2.392 (0.011)	0.039 (0.062)	1.462 (0.012)	1.956 (0.039)
Wald Test for long run Asym − metry	—	—	—	—	—	2.882 (0.021)	3.862 (0.096)	1.577 (0.029)	4.893 (0.076)	4.446 (0.056)
Cusum ($cusum^2$)	—	—-	—	—	—	S(s)	S(s)	S(s)	S(s)	S(u)

Source: Authors' Computation

*Note: (1) *, **, *** present the probability values of the co-efficient at 1%, 5% and 10% level of significance respectively (2) models 4, 5, 9 and 10 are without values because they failed the bound tests. See Table 4. (3) The autoregressive values were inadvertently omitted to minimize the incidence of auto-correction and multicollinearity.*

For simplicity and clarity, the results will be discussed as

a) Short-run Linear ARDL

These constitute the estimates of models 1-5. The results show that oil price shocks have mixed effects on this industrial subsector. These price shocks have negative impact on index of manufacturing output; electricity output and the index of mining and quarrying though statistically insignificant. On the contrary, these shocks have positive margined effect on building and construction and index of industrial output with values of 0.609 and 0.358 respectively albeit insignificant. These negative results agree with the findings of Olomola and Adejumo, 2006: Iwayami and Fowowe, 2011 as well as theoretical postulation of the negative relationship between oil price shocks industrial output. Theoretically, oil price shock is often considered as an adverse supply shock and is believed to cause a reduced level of output resulting from high cost of production. Apparently from the literature and in practical terms, the Nigerian industrial subsector output has continued to plummet during the period under review. This result could be explained by the neglect of the industrial sector (manufacturing) when crude-oil was discovered in commercial quantities in the early 1970s and subsequent in the price of crude oil internally.

B) Short Run Non-linear ARDL

This framework helps to disaggregate the impact of oil price shock into positive change (increase in oil price) and negative change (Decrease in oil price) in the short run. Positive oil price shock is expected to lead to higher government revenue, high inflation and cost of production and consequently decrease in output.

However the result from the asymmetric specification are mixed and variegated as shown in Table 5 shows that positive oil price shocks have some Marginal increase oil industrial output and its subsectors except mining and quarrying Icon and Effiom, (2019), had similar results, though these positive changes in industrial output indices are statistically insignificant. These increment ranges from 1.389 to 0.332 with the highest positive in building and construction output (1.389). Taney, *et al.* 2010 and Rafig, *et al*. and Akpan, 2009 had similar results. The positive oil price shocks over the years in Nigeria lead to higher government revenue hence higher expenditure and the high level of building and construction that followed was not unexpected. Also, Nigeria being and oil exporting and oil importing economy, and the results shows that oil price have a mild positive effect on the industrial sector resulting in the growth in light industries, in small and medium scale enterprises (SME), that dominates the industrial subsector of late.

Decrease in oil price has equivalent negative effects on the industrial sector and its components. The result shows that a decrease in oil price has a crowding out impact on industrial output. Virtually, all the coefficients are negative and statistically negative ranging from -0.444 to – 3.309 with the worst effect on manufacturing (-3.309). These results conform to the Adekunle and Ndukwe (2018), Ilechukwu and Nwokoye (2015). This negative relationship between oil price decrease and stunted industrial growth is contrary to theoretical expectations. A fall in oil price ought to stimulate industrial output through decrease in cost of production since Nigeria is import dependent in terms of intermediate products. These results could be adduced to the fact that oil price shocks affect the industrial production indirectly through it impact on exchange rate that remain all times high in Nigeria with negative effects on industrial output a midst reduction in oil price.

From the table, exchange rate and interest rate have mixed effects on industrial sector. Most of the estimates are positive against a 'priori expectations probably due to other intervening macroeconomic variables in the system; such as capacity utilization, fiscal and monetary incentives and business expectations.

(C), Diagnostic Tests

In this section, we aim to explore the suitability of linear and non-linear models to explain the effects of oil price shocks on the industrial subsector in Nigeria. In order to ascertain the reliability of the stated models, we performed diagnostic tests. A Cursory look at Table 5 shows that the error term coefficients meet a'priori expectations; being negative and fractional for both linear and non-linear models ranging from -0.032 to -0.090 with different degrees of speed of adjustment without significant difference between the linear ARDL and Non-linear ARDL estimates.

The statistically insignificance probabilities chi-squared for Lm test show that the residual in the respective models are uncorrelated and there are no problems of autocorrelation. The Ramsey RESET fitted squared value in Tables 5, show that some are more than 5 percent indicating problem of model misspecification in some of the models resulting probably from excessive use of lags in models 3, 6 and 9. Finding out if the coefficients of the regressors are changing systematically (CUSUM) or suddenly (CUSUM square), all the models are stable except model 10 whose regressors changed suddenly. The coefficients of the Error Correction Mechanism (ECM) measures the speed at which the dependent variable adjusts from short-run to its long-run equilibrium. The coefficient of the ECM for both ARDL and NARDL short-run equilibrium to long-run convergence are generally low ranging from -0.032 to -0.90 and do not discriminate between ARDL and NARDL.

The Wald test helps to confirm the asymmetric nature of the effect of increase in oil price (Positive) and decrease in oil price (Negative). Since the probability values of the wald test are less than 0.05 or 5 percent in all the models, suggests that the null hypothesis is rejected both in the short and long-run. This clearly confirmed that oil price surge (increase and decrease) have asymmetric effect in industrial output and its components. This Wald test results are similar to the findings of chuku *et al*. 2010, and Habihi, 2019.

5.2.2 Analysis of the Long-Run Symmetric and Asymmetric Effect of Oil Price Shocks on Industrial Subsector.

Table-6: presents the results of the long-run symmetric and asymmetric effects of oil price shocks on industrial subsector.

Table-6: Results of Long-Run ARDL and NARDL

	ARDL MODELS					NARDL MODELS				
Variables	**Model 1 IIP_t**	**Model 2 IMP_t**	**Model 3 $IBCP_t$**	**Model 4 IEP_t**	**Model 5 $IMQP_t$**	**Model 6 IIP_t**	**Model 7 IMP_t**	**Model 8 $IBCP_t$**	**Model 9 IEP_t**	**Model 10 $IMQP_t$**
OIP^{+}	-	-	-	-	-	-0.707	-0.659	1.414	-	-
OIP^{-}	-	-	-	-	-	0.799	1.874	1.336	-	-
OIP	0.692	-1.366	1.747	-	-	-	-	-	-	-
EXR	-1.671	-1.711	-0.891	-	-	0.092	0.440	-1.386	-	-
INT	-1.639	-0.306	-1.306	-	-	1.339	-1.006	1.391	-	-
Constant	2.190	0.332	1.389	-	-	0.161	2.039	1.386	-	-

Source: Authors Computation

Note: (1) *, **, *** present the probability values of the co-efficient at 1%, 5% and 10% level of significance respectively (2) models 4, 5, 9 and 10 are without values because they failed the bound tests. See Table 4. (3) The autoregressive values were inadvertently omitted to minimize the incidence of auto-correlation and multicollinearity.

Also, for clarity, the results will be discussed under the following subheadings

(a) Long-Run Linear ARDL

The estimates show that oil price shocks in a aggregative term (positive and negative) has a positive effects on index of industrial output (0.692) and index of building and construction (1.747) though statistically insignificant. The effect on index of manufacturing output is negative (-1.366).These results are not unexpected as the government has more funds from the oil revenue and thus, the manufacturing subsector was neglected. Olubousoye, et, al. 2015 had similar result and in conformity with theoretical expectations as price shock leads to increase in cost of production and hence reduction in output including manufacturing. The results also revealed an inverse relationship between exchange rate, interest rate and industrial output in conformity with a'priori expectations. Specifically, an increase in exchange rate and interest rate will reduce industrial output by 1.676 and 1.639 respectively. Manufacturing will fall by 1.711 and 0.306 units resulting from exchange rate and interest rate variations.

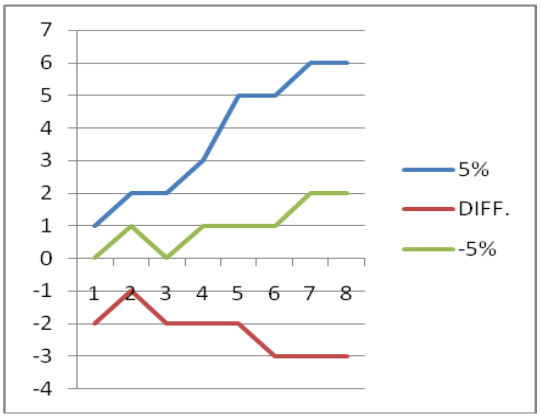
(b) Long-Run Non-Linear ARDL

On the other hand, the results of the asymmetric (non-linear) effect of oil price shocks on industrial output and its subsector are mixed and variegated. Specifically, if the price of oil appreciates by a unit, industrial output and manufacturing output will depreciate by 0.707 and 0.657 percentage respectively. However, building and construction maintain a positive relationship with oil price appreciation as government has enough revenue for road construction and other infrastructure in the system.

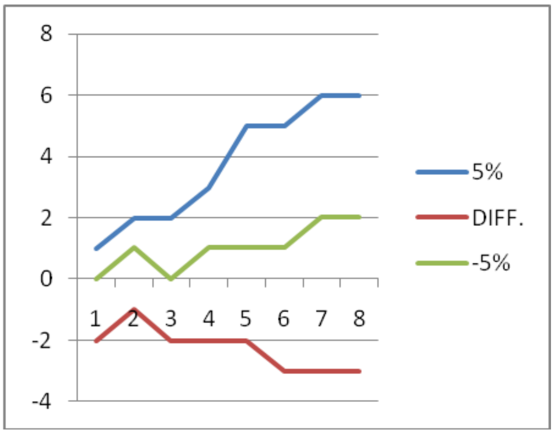
Decrease in the price of oil stimulates aggregate industrial output, manufacturing and building and construction by 0.799, 1.774 and 1.336 percent respectively. These results may not be unconnected with fall in the cost of production and inward looking policy of the government such as promotion of Small and Medium Enterprises (SME) and revitalization of Bank of Industry (BOI). These results further confirm the asymmetric nature of the effect of oil price shock on the Nigerian industrial subsector.

The dynamic multipliers in figure 2 explain the responses of Nigerian industrial subsector output to both positive and negative oil price shocks. Aggregate industrial production and manufacturing production respond slowly and positively to negative oil price shocks and negatively to positive oil price shocks in conformity with empirical estimates and contrary to theoretical expectations. We also observed that industrial output and manufacturing output respond more to positive shocks than to negative shocks and positive responses are short lived. The response of building and construction to both shocks is positive though slow. There is a quick adjustment back to equilibrium state for both electricity output and mining and quarrying output.

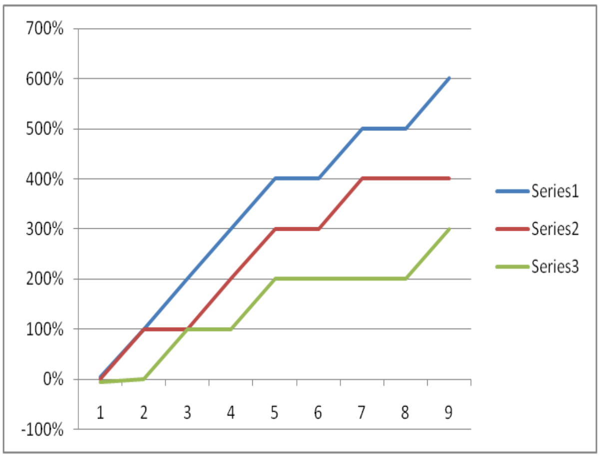
INDUSTRIAL RESPONSE TO OIL PRICE



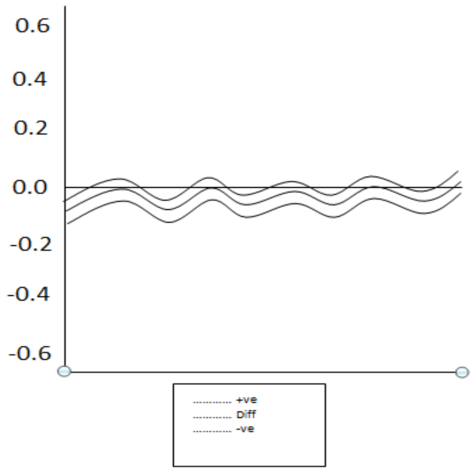
MANUFACTURING RESPONSE TO OIL PRICE



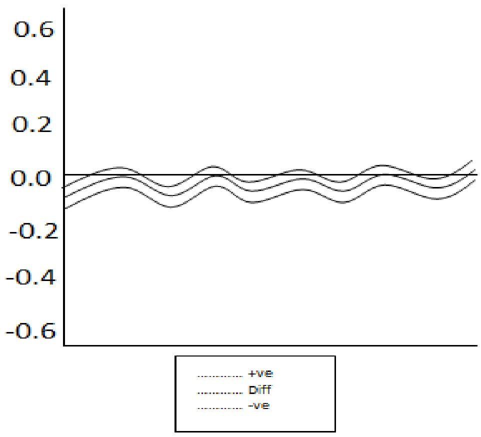
BUILDING AND CONSTRUCTION RESPONSE TO OIL PRICE



ELECTRICITY OUTPUT RESPONSE OF OIL PRICE



MINING AND QUARRYING RESPONSE TO OIL PRICE



(6) Concluding Remark

In this study, we were inspired to capture linear and non-linear (if any) relationship between oil price shocks and industrial subsectors and its constituents. Therefore, we build ARDL and NARDL, models based on the standard neoclassical production function by Solow (1956).

The results of the short run-linear ARDL model revealed that oil price dynamic have negative effect on index of manufacturing output, electricity and index of mining and quarrying and contrarily have positive marginal effect on building and construction and aggregate industrial output. This marginal positive impact of oil price shocks on industrial output was further reinforced in the short-run non-linear model though statistically insignificant, while decrease in price of oil shocks off industrial output against theoretical expectation. The impact of exchange rate and lending interest rate on industrial output and its constituent are mixed with most estimates being positive though insignificant. Similar to the short-run results, the long-run results show that oil price shocks (increase and decrease) have variegated affects on Nigeria industrial subsectors and it constituents. The positive marginal effect of oil price dynamic on Nigerian industrial sector of the short-run dovetailed into long-run though statistical insignificant.

The test of asymmetry as shown by wald test, suggested that oil price variation (increase or decrease) have differentiated effects on the performance of industrial subsector in Nigerian as increase in the price of oil dampened aggregate industrial output and manufacturing output with marginal increase in building and construction output, contrarily a decrease in oil price that stimulates industrial, manufacturing building and construction output in the long-run though short lived compared to the negative effects. In the light of this empirical finding, it is clear that oil price dynamics (increase or decrease) have mixed and variegated effects on Nigerian industrial sector and its disaggregated component parts. Consequently, Nigerian government and the allied policy makers should formulate appropriate trade and industrial policies coupled with sound management mechanism to effectively maximize the volatility of oil price so as to mitigate its negative impact on the Nigerian industrial subsector, The policy options include establishment of light industry, promotion of small and medium scale enterprises and proper funding Bank of Industry (BOI) during period of oil boom and consequently be able to compete favourably with their foreign counterparts irrespective of the price of oil at all times.

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Cite This Article: Iganiga, B.O. *et al* (2021). Oil Price Shocks and Industrial Output in Nigeria; is The Relationship Linear?. *East African Scholars J Econ Bus Manag, 4*(11), 250-262.