Oil-Growth nexus in Nigeria: An ADL-MIDAS Approach

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Highlights

•The nexus between Oil price and real GDP growth of Nigeria is examined.
•The ADL variant of MIDAS regressions is employed.
•Aggregate real GDP growth responds asymmetrically to changes in oil price.
•Higher agricultural sector output growth is observed when oil price reduces.
•Greater private participation in the economy is encouraged amid dwindling oil price.

Abstract

In this study, we investigate the effect of oil price on the real GDP growth of Nigeria. We contribute to the extant literature on oil price-growth nexus in three ways. First, we employ one of the recently developed Mixed Data Sampling models owing to its ability to accommodate mixed data frequencies. Second, we examine the impact of crude oil price on aggregate as well as sectoral output growth, with focus on agriculture, industry and service sectors. Third, we account for the role macroeconomic/control variables and crude oil price asymmetry. Our results show that accounting for crude oil price asymmetry and macroeconomic determinants increases the predictability of the ADL-MIDAS model for the analysis of oil price-growth nexus. On the aggregate, we find that negative oil price changes significantly reduce economic growth while positive oil price changes do not increase economic growth significantly. The sectoral analyses show that the service and industry sectors are more affected by the negative oil price changes than the agriculture sector. Overall, we conclude that the impact of government participation in the economy remains huge and the situation whereby recurrent to capital expenditure ratio of government is about 80/20 percent dampens the growth potential of the Nigerian economy. More investment in capital infrastructure relative to recurrent expenditure is recommended, to reduce the adverse effect of negative crude oil price on economic growth in Nigeria.

Keywords: Oil price, Economic growth, ADL-MIDAS, Oil price asymmetry, Macroeconomic/control variables

JEL Codes: C18, E20, Q41.

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1. Introduction

Crude oil is one of the most important economic resources in the world. It is a source of energy to several equipments and machines used for day-to-day economic activities; hence, the far-reaching economic implications of oil price are not unexpected. As a natural resource not evenly distributed across the globe, crude oil is one of the most traded goods in the world. For example, crude oil exports in 2018 totalled about US$1.1 trillion, which is nearly 6% of global trade in goods[5]. For most of the oil-rich nations including Nigeria, national planning for economic growth and development is usually dependent on revenue from export of crude oil, making economic growth vulnerable to oil price shocks. Theoretically, the relationship between oil price and economic growth has been explained based on the demand and supply side effects of changes in oil price (Yazdan et al., 2012). On the demand side, an increase in oil price raises transaction costs which consequently lowers aggregate demand due to increased prices of goods and services. The supply side effect views oil as an input in the production process. Thus, an increase in oil price leads to higher production costs which limits the supply of goods and services and by extension lowers aggregate output. The demand and supply side effects point to a negative effect of oil price on economic growth.

Generally, empirical results on the relationship between oil price and economic growth have been mixed (for negative relationship, see Van Eyden et al. (2019), Zulfigarov and Neuenkirch (2020) and Guan et al. (2021); for positive relationship, see for example, Aregbeyen and Kolawole (2015), Fasanya and Ogundare (2018), Wesseh Jr. and Boqiang (2018), Mo et al. (2019) and Musa et al. (2019); and for insignificant relationship, see Olomola and Adejumo (2006), Yazdan et al. (2012), Idrisov (2015), Gummi et al. (2016) and Akinsola and Odhiambo (2020)). A number of studies that do not specify the direction of oil price effect on economic growth but only establish causality between them include, but not limited to, Hanabusa (2009), Lee and Chiu (2011), Bildirici and Ersin (2015), Bergmann (2019), Mensah et al. (2019), Kırca et al. (2020) and Maheu et al. (2020).

Meanwhile, most of the earlier studies on oil price-growth nexus constrict oil price data (high frequency data) to the same frequency as the economic growth (low frequency data), which may bias the results due to loss of oil price information. For example, oil price data that can be obtained

[5] See: https://www.hinrichfoundation.com/research/wp/sustainable/the-oil-price-war-and-global-trade/

on monthly was constricted to quarterly frequency in Kırca et al. (2020), Narayan et al. (2014), Olomola and Adejumo (2006), and Zulfigarov and Neuenkirch (2020), and constricted to annual frequency in many other studies (see Lee and Chiu, 2011; Yazdan et al., 2012; Bildirici and Ersin, 2015; Gummi et al., 2016; Sarwar et al., 2017; Shahbaz et al., 2017; Wesseh Jr. and Boqiang, 2018; Bergmann, 2019; Jawadi and Ftiti, 2019; Mensah et al., 2019; Musa et al., 2019; Van Eyden et al., 2019; Akinsola and Odhiambo, 2020; Guan et al., 2021; among others).

The main contribution of this study is to better explore ample available oil price information in the analysis of oil price – economic growth relationship, which is expected to offer better outcomes. Hence, this study deploys the Autoregressive Distributed Lag – Mixed Data Sampling (ADL-MIDAS) model by Ghysels et al. (2002, 2006, 2007) in analyzing the relationship. This method has been found very useful in explaining the determinants of economic growth in the face of mixed data frequencies (see for example, Salisu and Ogbonna, 2019). The second contribution of this study relates to the impact of crude oil price on real sectoral output growth, with focus on agriculture, industry and service sectors. This study provides new evidence in this respect, as earlier studies on the impact of crude oil price on output growth in Nigeria are conducted on aggregate real GDP growth (see for example, Olomola and Adejumo, 2006; Akinsola and Odhiambo, 2020). The third contribution involves accounting for the role macroeconomic/control variables as well as crude oil price asymmetry. The significance of accounting for these economic properties has been appreciated in the literature (see Salisu et al., 2019), however, these have not been captured by earlier studies on the relationship between crude oil price and economic growth in Nigeria.

This study is divided five sections. Following this introductory section, section 2 explains the ADL-MIDAS model and method of analysis. Section 3 deals with data issues and preliminary analysis. Section 4 presents and discusses empirical results, while section 5 concludes the study.

2. Method and Model

As discussed earlier, this study employs the Autoregressive Distributed Lag – Mixed Data Sampling (ADL-MIDAS) technique. This MIDAS approach follows Ghysels et al. (2002, 2006, 2007) and Andreou et al. (2010) and it allows for data sampled at different frequencies to be used

in the same regression. The motivation for this technique lies in its ability to incorporate the information in the higher frequency data into the lower frequency regression in a simple and parsimonious fashion (Ghysels et al., 2007). The simple MIDAS appears in a distributed lag form, given that the dependent variable in one period is explained by more than one lags of the (higher frequency) independent variable.

In this study, the dependent variable is in quarterly frequency while the independent variable is in monthly frequency. This suggests that for a dependent variable, y_t, available once between time t and t-1, the independent variable, x_t^m, is observed $m=3$ times in the same period. Hence, the dynamic relationship is between y_t and x_t^m. The distributed lag relation exists as we manage to project the left-hand variable y_t onto a history of lagged observations of $x_{t-j/m}^{(m)}$. The superscript on $x_{t-j/m}^{(m)}$ denotes the higher sampling frequency, and its exact timing lag is expressed as a fraction of the unit interval between t − 1 and t. Thus, j will range from 1 to 3 between t − 1 and t, thereby generating three coefficients for the relationship between the dependent and the independent variables in one quarter. A simple MIDAS model is

$$y_t = \beta_0 + \beta_1 B\left(L^{1/m};\theta\right)x_t^{(m)} + \varepsilon_t^m \qquad (1)$$

for $t=1,...,T$, where $B\left(L^{1/m};\theta\right)=\sum_{k=0}^{K} B\left(k;\theta\right)L^{k/m}$, and $L^{1/m}$ is a lag operator such that $L^{1/m}x_t^{(m)} = x_{t-1/m}^{(m)}$; the lag coefficients in $B\left(k;\theta\right)$ of the corresponding lag operator $L^{k/m}$ are parameterized as a function of a small dimensional vector of parameters θ. Finally, the parameter β_1 captures the overall impact of lagged $x_t^{(m)}$'s on y_t. This is identified by normalizing the function $B\left(L^{1/m};\theta\right)$ to sum to unity (see Ghysels et al., 2007).

Given the motivation for this study, equation (1) is modified to allow for autoregressive representation of the dependent variable, to capture potential problem of persistence in the level of real GDP. Therefore, the autoregressive augmented MIDAS model can be represented as

$$y_{t+1} = \beta_0 + \gamma y_t + \beta_1 B\left(L^{1/m};\theta\right)x_t^{(m)} + \varepsilon_{t+1} \qquad (2)$$

where γ is the measure of persistence in the level of real GDP and other variables are as previously defined. This study employs Almon Polynomial Distributed Lags (PDL) weighting form in

dealing with the potential problem of over-parameterization. Thus, the ADL-MIDAS specification for the relationship between oil price and economic growth in this study is presented in equation (3):

$$rgdpg_{t+1}^{Q} = \lambda + \sum_{i=1}^{p_{GDP}^{Q}-1} \alpha_i rgdpg_{t-i}^{Q} + \left[\sum_{j=0}^{k} \tau^j \theta_j\right] \sum_{i=0}^{q_{opr}^{M}-1} opr_{N_M-\tau,t-i}^{M} + \xi_{t+1} \quad (3)$$

where the dependent variable, $rgdpg$, is real GDP growth and the independent variable opr is the Nigeria's bonny light crude oil price. The superscripts/subscripts M and Q indicate monthly and quarterly frequencies, respectively. In the Almon approach, the coefficients of the delayed/lagged terms $\left[\sum_{j=0}^{k} \tau^j \theta_j\right]$ are designed as polynomial varying weights (see Karagoz and Ergun, 2020). The sum of the Almon lag coefficients represents the slope parameter (β_1) in equations 1 and 2. Notably, while Almon approach determines the overall effect of high frequency variable on low frequency variable through PDL[6], this is determined directly by alternative approaches such as exponential Almon and Beta weighting schemes. However, the methods assume common slope for all the high frequency regressors, which is an unnecessary restriction.

More so, as oil prices have been widely observed to possess asymmetric effects (see, Salisu et al., 2017), this study accounts for oil price asymmetry by decomposing oil price into negative and positive oil price changes using partial sum approach by Shin et al. (2014). The asymmetric components of the oil prices are computed as follows:

$$opr_t^{+} = \sum_{k=1}^{t} \Delta opr_k^{+} = \sum_{k=1}^{t} \max\left(\Delta opr_k^{+}, 0\right) \quad (4)$$

$$opr_t^{-} = \sum_{k=1}^{t} \Delta opr_k^{-} = \sum_{k=1}^{t} \min\left(\Delta opr_k^{-}, 0\right) \quad (5)$$

where equations (4) and (5) are the positive and negative partial sum decompositions of changes in oil price respectively. Thus, we further modify equation (3) to explain the effect of positive and negative oil price changes on real GDP growth by respectively substituting equations (4) and (5) for oil price in equation (3). The asymmetric ADL-MIDAS model is expressed as follows:

[6] See Salisu and Gupta (2020), EViews 10 User's Guide II, pp.329.

$$rgdpg_{t+1}^{Q} = \lambda + \sum_{i=0}^{p_{GDP}^{Q}-1} \alpha_i rgdpg_{t-i}^{Q} + \left[\sum_{j=0}^{N_M-1} \tau^j \theta_j^{(+)}\right] \sum_{i=0}^{q_{opr}^{M}-1} opr_{N_M-\tau,t-i}^{(+)M} + \left[\sum_{j=0}^{N_M-1} \tau^j \theta_j^{(-)}\right] \sum_{i=0}^{q_{opr}^{M}-1} opr_{N_M-\tau,t-i}^{(-)M} + \varepsilon_{t+1} \quad (6)$$

where equation (6) is an alternative model that deals with oil price asymmetry. There is evidence of oil price asymmetry on Nigeria's economic growth if the β^+ (that is, $\left[\sum_{j=0}^{N_M-1} \tau^j \theta_j^{+}\right]$) and β^- (that is $\left[\sum_{j=0}^{N_M-1} \tau^j \theta_j^{-}\right]$) are statistically different from each other; otherwise their effect on growth is considered identical. Notably, equations (3) and (6) represent the symmetric and asymmetric ADL-MIDAS respectively. While equations (3) and (6) have no control variables, we construct additional models to account for the role of relevant macroeconomic variables such as real interest rate and real exchange rate (see also, Salisu et al., 2019). The sectoral analysis proposed in addition to the aggregate analysis will be conducted by replacing the dependent variable with the growth rates of the output in three main sectors; Agriculture, Industry and Services.

3. Data issues and Preliminary Analysis

The data used for analysis in this study consists primarily of quarterly aggregate and sectoral GDP of Nigeria and crude oil price benchmark for the country; the Bonny light oil price. We employ post-GDP rebasing data for the aggregate and sectoral economic output, thus, the data scope is between 2010Q1 and 2021Q1 for quarterly frequency and 2010M01 to 2021M03 for monthly frequency. Consequently, we obtain 45 observations for the former and 135 observations for the latter while we source the data from CBN database including its Statistical Bulletin. Following the Keynesian growth model, real interest rate and real exchange rate are considered as control variables. The real interest rate is computed as maximum lending rate minus inflation rate, while real exchange rate is computed as the product of nominal exchange rate and the ratio of US consumer price index to Nigeria consumer price index, while nominal exchange rate is defined as the Bureau de Change (BDC) exchange rate of Naira per unit of US dollar. The data for maximum lending rate, inflation rate, BDC exchange rate and Nigeria's consumer price index are obtained

from CBN statistical bulletin, while the data for the US consumer price index are obtained from the US Federal Reserves. Aggregate and sectoral output growth is computed as:

$$output\ growth = 100 * \left((Q_t - Q_{t-4}) / Q_{t-4} \right) \quad (9)$$

where Q indicates quarterly aggregate or sectoral real GDP in Billion Naira.

Figures 1-4 present the graphs showing the relationship between GDP growth (aggregate and sectoral) and Bonny light oil price. Figure 1 shows evidence of positive association between oil price and real GDP growth in Nigeria. This relationship is more obvious between 2014 and 2016, when crude oil price crashed from US$114.6/barrel in June 2014 to US$47.43/barrel in September 2016 and the real GDP growth of Nigeria fell from 6.54 percent in 2014Q2 to -2.34% 2016Q3. The clear positive association is also observed between crude oil price and the output growth of manufacturing and service sectors, as evident in Figures 3 and 4, respectively. The positive association between crude oil price and the output growth agriculture sector appears weak, as Figure 2 shows that the positive co-movement between the two variables is not apparent.

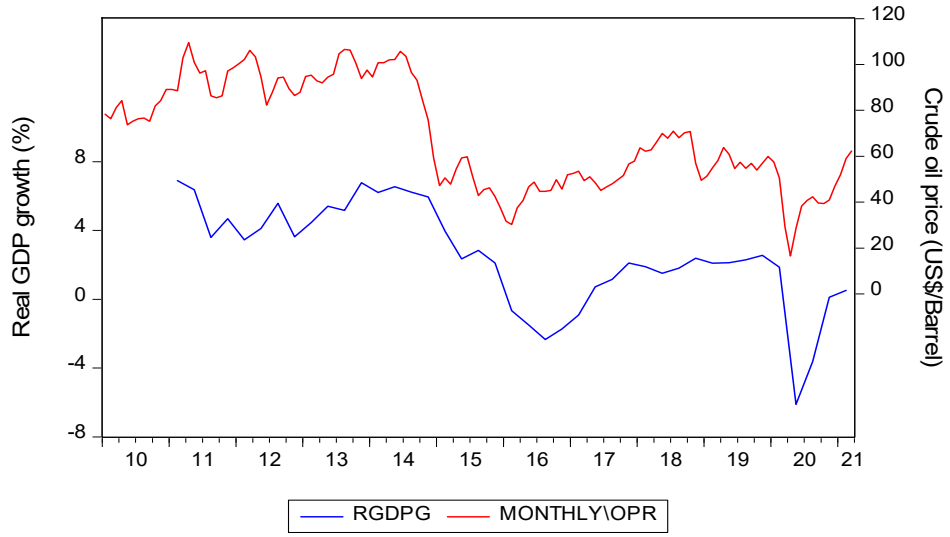

Figure 1: Oil Price and Real GDP growth in Nigeria

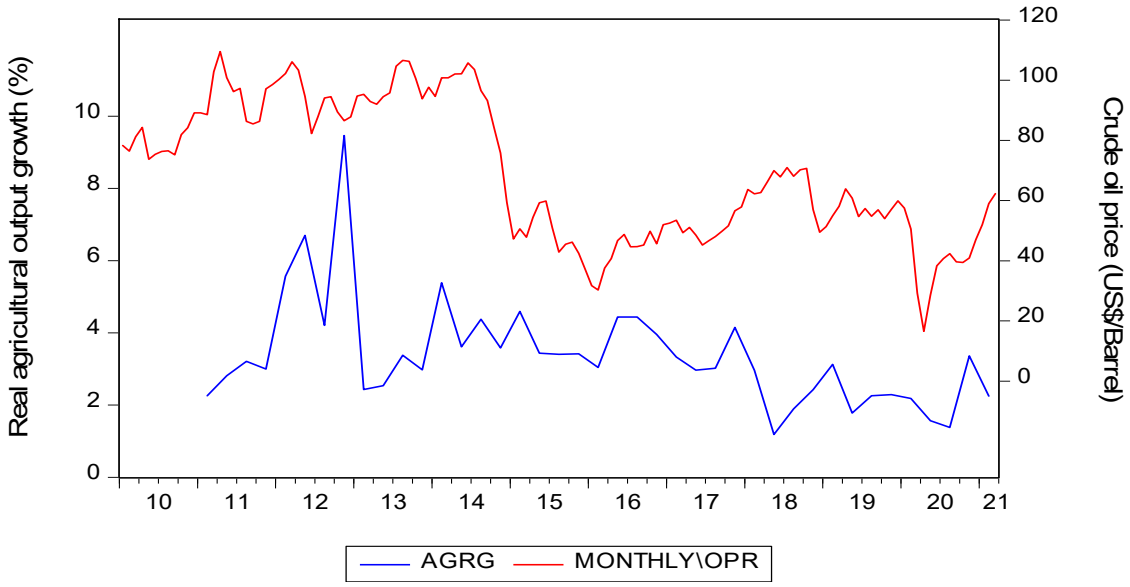

Figure 2: Oil price and the output growth of agriculture sector in Nigeria

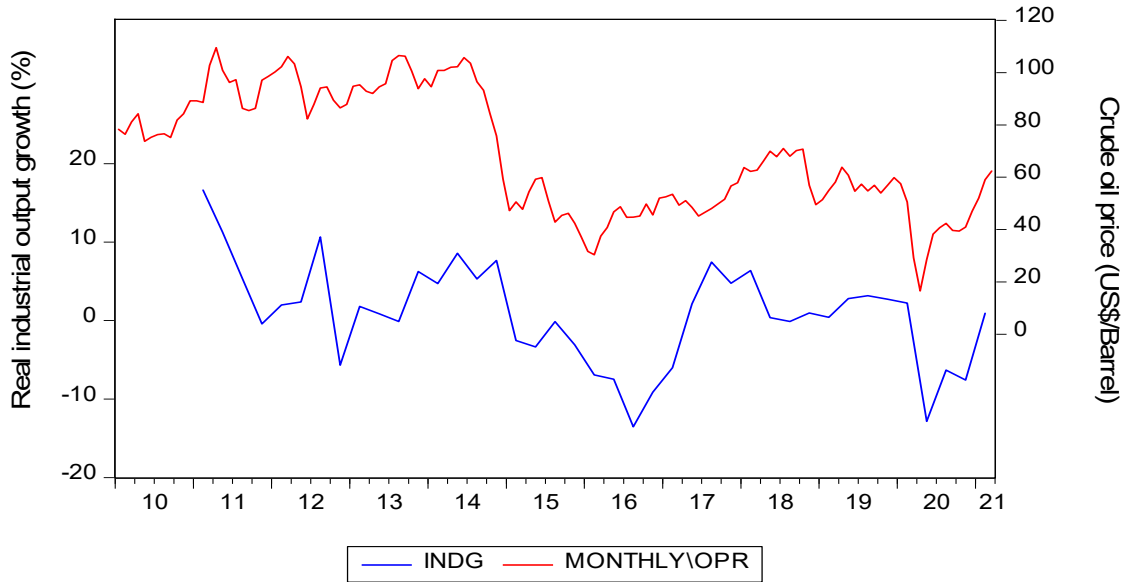

Figure 3: Oil Price and the output growth of industry sector in Nigeria

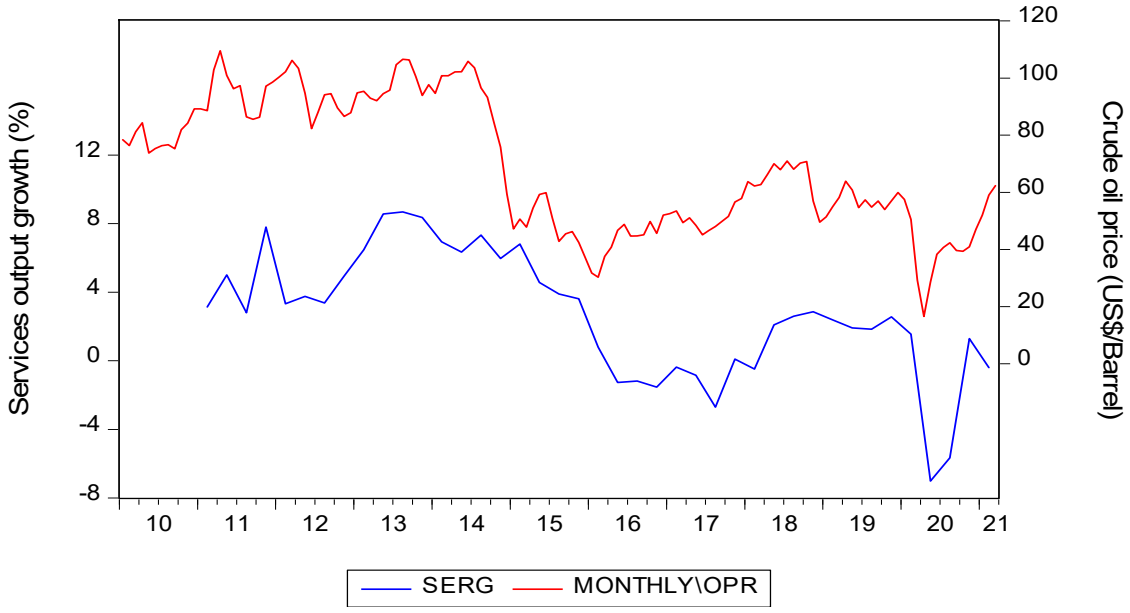

Figure 4: Oil Price and the output growth of service sector in Nigeria

Table 1 presents the descriptive statistics of the output growth variables in quarterly frequency, and the predictor series (i.e., crude oil price, real interest rate and real exchange rate) in monthly frequency for the period 2010Q1 to 2021Q1. Given the way the aggregate and sectoral real GDP growth series are computed, values for the four quarters of 2010 are suppressed from the estimation process. Hence, we have 41 quarters for both aggregate and sectoral real GDP growth. From the table, it can be observed that the mean value of real GDP growth is 2.5%, suggesting that Nigeria's real GDP grows at 2.5% on the average between 2011Q1 and 2021Q1, despite the 2016 and 2020 recessions. The maximum real GDP growth during this period is 6.9%, which is observed in 2011Q1, and the lowest real GDP growth rate is -6.1%, observed during the 2020 recession. The kurtosis statistic shows that the aggregate real GDP growth series has positive excess kurtosis (0.290) with the kurtosis statistic of (3.290), while the skewness statistic shows that it is negatively skewed (-0.654). Despite the negative skewness and positive excess kurtosis, the Jarque-Bera statistic shows that the distribution of the real GDP series is not significantly different from a normally distributed series, as the null hypothesis of normality cannot be rejected.

Table 1: Descriptive Statistics

	Quarterly frequencies				Monthly frequencies		
Statistics	**RGDPG**	**AGRG**	**INDG**	**SERG**	**OPR**	**RER**	**RINT**
Mean	2.502	3.442	0.997	2.796	76.796	153.664	14.718
Median	2.355	3.172	0.949	2.853	69.680	145.718	15.486
Maximum	6.892	9.925	18.086	9.083	128.000	264.182	20.188
Minimum	-6.104	1.192	-12.659	-6.779	14.280	117.655	7.684
Std. Dev.	2.992	1.577	6.446	3.750	28.126	30.323	3.592
Skewness	-0.654	1.917	0.072	-0.338	0.170	1.514	-0.293
Kurtosis	3.290	8.489	3.189	2.895	1.762	5.594	1.799
Jarque-Bera	3.067	76.585	0.096	0.798	9.264	89.383	10.040
Probability	0.216	0.000	0.953	0.671	0.010	0.000	0.007
Observations	41	41	41	41	135	135	135

Note: Aggregate real GDP growth (RGDPG), Agricultural sector real GDP growth (AGRG), Industrial sector real GDP growth (INDG) and Service sector real GDP growth (SERG) are measured in percentages (%). Crude oil price (OPR) is the bonnylight crude oil price measured in US$ per barrel. Real exchange rate (RER) is measured in index of domestic price of basket of foreign goods, as nominal exchange rate is the BDC rate in Naira per unit of US dollar. An increase in RER implies RER depreciation, while a decrease implies RER appreciation. Real interest rate (RINT) is the difference between maximum lending rate and inflation rate in Nigeria over the sample period.

Furthermore, agricultural output has the highest growth on the average (3.44%) compared to other sectors; industrial output growth (about 1%) and service output growth (2.8%). Despite the 2016 and 2020 economic recessions, the minimum growth of the agricultural output does not turn negative unlike the industrial and service sectors with negative growth in 2016Q3 and 2020Q2, respectively. However, as revealed by the normality test using Jarque-Bera statistic, industrial and service growth series are normally distributed unlike the agricultural sector growth series which is not normally distributed due to excess kurtosis and positive skewness.

As regards the monthly frequency data comprising the main explanatory variable; crude oil price, and the control variables; real exchange rate and real interest rate, the null hypothesis of normality can be rejected, implying that they are not normally distributed. The average value of the bonnylight crude oil price over the period of study is US$76.8/barrel, while the average values of real exchange rate and real interest rate are 153.7 basis points and 14.72%, respectively. The minimum crude oil price is US$14.28/barrel observed in 2020Q4. Notably, the aggregate and sectoral economic growth depressed in the same 2020. This further demonstrates potential positive relationship between crude oil price and real GDP growth in Nigeria.

4. Presentation and Discussion of Results

This section presents and discusses empirical results for the analysis of the effect of oil price on economic growth in Nigeria; focusing on aggregate and sectoral output growth. The ADL-MIDAS results for this analysis are presented in Tables 2 to 5. For parsimony, the ADL MIDAS is estimated with Almon polynomial lag of degree 2[7]. Thus, the effect of each explanatory variable is determined by the sum of the coefficients of the two polynomial degrees; PLD01 and PLD02. For test of coefficient stability, the ADL-MIDAS is estimated with and without control variables. In this case, the ADL-MIDAS with control variable will be the preferred model if at least one control variable is statistically significant. The overall performance of the models is evaluated using relevant statistical tools such as R^2, Durbin Waston (D.W) statistic, Akaike Information Criterion (AIC) and Swartz Information Criterion (SIC). The preferred model is expected to have a higher coefficient of determination (R^2) closer to 1, D.W statistic closer to 2, and a lower AIC/SIC. Aside from the use of relatively full available information made possible by ADL-MIDAS, one other contribution of this study is that it accounts for oil price asymmetry in modelling oil price- economic growth nexus using ADL-MIDAS. Hence, we estimate ADL-MIDAS with and without accounting for oil price asymmetry. The rejection of symmetric null hypothesis will imply that ADL-MIDAS with asymmetry is the preferred model.

Table 2 presents the ADL-MIDAS results for the effect of crude oil price on the (aggregate) real GDP growth in Nigeria. From the basic result with symmetric oil price and no control variable, the study shows that crude oil price has positive effect on economic growth in Nigeria. This result is consistent under the model with control variables, suggesting that the result is robust to the choice of model type (bivariate or multivariate). Meanwhile, under Panel B where the role of oil price asymmetry is observed, the result shows evidence of significant asymmetric effect, as the null hypothesis that the difference between the effects of positive and negative oil price on real GDP growth is not significantly different from zero is rejected. Evidence of asymmetric effect is revealed both under models with and without control variables. However, comparing all the four models presented in Table 2, the AIC statistic for the model that accounts for the role of control variables and asymmetric effects is the lowest. This implies that accounting for oil price asymmetry and the role of control variables enhances the efficiency of oil price model- output growth nexus.

[7] Almon polynomial lag of degree 3 is only considered when model efficiency is not achieved at Almon PDL 2.

Table 2: Results for real GDP growth and oil price nexus in Nigeria

		Without control		With control	
Variables		**Lags**	**Coeff.**	**Lags**	**Coeff.**
Panel A: With symmetric oil price					
Constant			-2.0765***		-1.7411
			(0.7011)		(3.9447)
Real GPD growth(-1)			0.5329***		0.4721***
			(0.1071)		(0.1204)
Bonnylight oil price			0.1240***		0.1278***
			(0.0308)		(0.0310)
	PDL01	2	0.3318***	2	0.3455***
			(0.0931)		(0.0938)
	PDL02		-0.2078***		-0.2177***
			(0.0626)		(0.0633)
Model Diagnostics					
R^2			0.8225		0.8508
D.W			1.8546		2.0544
AIC			3.4712		3.4924
SIC			**3.6384**		3.8268
Panel B: With Asymmetric oil price					
Constant			1.3262		5.3188
			(0.9970)		(3.8708)
Real GPD growth(-1)			0.4937***		0.2510
			(0.1166)		(0.1577)
Positive Bonnylight oil price			0.0310		0.0200
			(0.0593)		(0.0204)
	PDL01	4	0.1932	12	0.0336
			(0.2779)		(0.0308)
	PDL02		-0.2071		-0.0148
			(0.2821)		(0.0118)
	PDL03		0.0450		0.0013
			(0.0575)		(0.0009)
Negative Bonnylight oil price			0.2052***		0.2000***
			(0.0467)		(0.0432)
	PDL01	4	1.1258***	3	1.2784***
			(0.3792)		(0.3600)
	PDL02		-1.1948**		-1.4152***
			(0.4545)		(0.4305)
	PDL03		0.2742**		0.3367***
			(0.1144)		(0.1080)
Asymmetric test: H_0: oilp_p - oilp_n=0			-0.1742**		-0.1799***
			(0.0846)		(0.0482)
Model Diagnostics					
R^2			0.8473		0.9008
D.W.			2.0695		2.1333
AIC			3.4934		**3.3624**
SIC			3.8311		3.9535

Note: This table presents the ADL-MIDAS results for the effect of crude oil price on aggregate real output growth in Nigeria with and without control variables as well as with and without accounting for oil price asymmetry. For parsimony, ADL MIDAS is estimated with polynomial degree (PLD/Almon) 2 (or 3 when lag 2 is not efficient). Thus, the effect of each explanatory variable is determined by the sum of the coefficients of the two polynomial degrees; PLD01 and PLD02. This is determined using Wald test. The lag length used is the optimal lag for the independent

variable. Values in parenthesis indicate standard error of the corresponding coefficient. Asterisks ***, ** and * indicate statistical significance at 1%, 5% and 10% level, respectively.

Apparently, the result shows that negative crude oil price has positive effect on aggregate economic growth in Nigeria, and the effect of positive crude oil price on aggregate economic growth is not significant. As positive effect of negative crude oil price suggests that negative crude oil price moves in the same direction with real GDP growth, it implies that falling crude oil price causes significant reduction in real GDP growth in Nigeria, whereas, increases in crude oil price do not seem to improve the level of real GDP growth. This result can be explained by the role of government as the highest employer of labour in the Nigerian economy. Falling crude oil price implies that low revenue is accumulated to the government. This will lead to low government expenditure, owing of salaries and overall reduction in aggregate demand, which will eventually cause economic growth to decline. Failure of increases in crude oil price to have significant impact of economic growth suggests that Nigeria has not made good use of past increases in crude oil price to develop necessary human and physical infrastructure to enhance economic growth in the country. This is justified given the level of infrastructural development in similar oil-rich countries such as Saudi Arabia and United Arab Emirate.

Table 3 presents the results for the effect of crude oil price on agricultural sector output growth in Nigeria. From the results, it can be observed that the basic (no control) ADL-MIDAS models with and without asymmetry reveal that oil price has no significant impact on real agricultural sector output growth. The insignificance of both positive and negative oil prices and the insignificance of their difference reveal that there is no oil price asymmetry in the crude oil price – agricultural output growth nexus for Nigeria. This result fairly supports our preliminary analysis, where weak degree association between agricultural output growth and crude oil price is observed. However, accounting for the role of control variables slightly improves the efficiency of crude oil price at influencing agricultural sector output growth. Particularly, the model with control variables and asymmetry shows that the negative effect of negative changes in oil price on agricultural sector output growth is statistically significant at 10%. This level of significance appears too weak to reject asymmetric test hypothesis. Thus, we can conclude that both positive and negative oil prices do not have significant effect on agricultural sector output growth. Overall, the model with control variables and oil price asymmetry is adjudged to be the best among the competing models (with

its lowest AIC value), which is consistent with discovery under the aggregate output growth results. This implies that accounting for oil price asymmetry and the role of control variables is important when dealing with oil price-growth nexus. The insignificant effect of oil price on agricultural sector output growth is not surprising as agricultural sector is dominated by small scale investors which produce with less reliance government funding and social infrastructure.

Similarly, Table 4 shows the results of the effect of crude oil price on real industrial output growth in Nigeria. In Panel A which shows the basic ADL-MIDAS models, the result from the model without control variables reveals that oil price has significant (at 5%) positive impact on real industrial output growth. This is consistent with the result obtained when we account for the role of macroeconomic variables, although at a lower level of significance (10%). This implies that the higher (lower) the oil prices, the higher (lower) the real industrial output growth. In Panel B where the results of the ADL-MIDAS with crude oil price asymmetry are presented, the evidence is mixed and inconsistent. On the one hand, the asymmetric model without control variables reveals that there is no asymmetric effect, although negative oil price is significant while positive oil price is not. On the other hand, the asymmetric model with control variables shows that there is significant asymmetry even though both positive and negative oil price changes have significant positive effect. Comparing the model evaluation criteria for the four models, we observe that models without asymmetric effects are preferred in this case. While the AIC favours the basic model with control variables, SIC favours the basic model without control variables. Thus, amidst no significant asymmetric effect, the result shows that oil price has significant positive effect on industrial output growth in Nigeria. This result is not surprising, as the economy generally experiences relative stability in the prices of industrial energy inputs such as petrol, coal, and gas in the period of crude oil price increases, thus allowing fair improvement in the real industrial output growth. Distortions in government finances due to falling oil price are shifted to the industries in form of higher taxes and running costs, which will cause contraction in industrial sector output growth.

Table 3: Results for Agricultural sector output growth and oil price nexus in Nigeria

	Without control		With control	
Variables	**Lags**	**Coeff.**	**Lags**	**Coeff.**
Panel A: With symmetric oil price				
Constant		1.2176		-2.8861
		(0.7720)		(4.9957)
Real agricultural output growth(-1)		0.1565		-0.1769
		(0.1613)		(0.1724)
Bonnylight oil price		-0.0010		-0.0064
		(0.0042)		(0.0048)
[PDL01]	12	-0.0015	12	-0.0085
		(0.0050)		(0.0057)
[PDL02]		0.0005		0.0021**
		(0.0008)		(0.0009)
Model Diagnostics				
R^2		0.2088		0.4345
D.W.		2.0724		2.0650
AIC		3.7004		3.5646
SIC		**3.8693**		3.9023
Panel B: With Asymmetric oil price				
Constant		6.0294***		-3.4150
		(1.3257)		(5.9050)
Real agricultural output growth(-1)		0.06260		-0.2311
		(0.1607)		(0.1707)
Positive Bonnylight oil price		-0.0132		-0.0098
		(0.0094)		(0.0192)
PDL01	12	-0.0153	8	-0.0140
		(0.0110)		(0.0244)
PDL02		0.0022		0.0043
		(0.0017)		(0.0053)
Negative Bonnylight oil price		0.0232		-0.0105*
		(0.0226)		(0.0055)
PDL01	4	0.0392	12	-0.0132*
		(0.0376)		(0.0066)
PDL02		-0.0160		0.0028**
		(0.0150)		(0.0011)
Asymmetric test: H_0: oilp_p-oilp_n=0		-0.0364		0.0007
		(0.0261)		(0.0198)
Model Diagnostics				
R^2		0.3223		0.4970
D.W.		2.0264		2.1956
AIC		3.6456		**3.5475**
SIC		3.8989		3.9698

Note: This table presents the ADL-MIDAS results for the effect of crude oil price on real agricultural sector output growth in Nigeria with and without control variables as well as with and without accounting for oil price asymmetry. For parsimony, ADL MIDAS is estimated with polynomial degree (PLD/Almon) 2 (or 3 when lag 2 is not efficient). Thus, the effect of each explanatory variable is determined by the sum of the coefficients of the two polynomial degrees; PLD01 and PLD02. This is determined using Wald test. The lag length used is the optimal lag for the

independent variable. Values in parenthesis indicate standard error of the corresponding coefficient. Asterisks ***, ** and * indicate statistical significance at 1%, 5% and 10% level, respectively.

Table 4: Results for industrial sector output growth and oil price nexus in Nigeria

		Without control		With control	
Variables		**Lags**	**Coeff.**	**Lags**	**Coeff.**
Panel A: With symmetric oil price					
Constant			-4.3239*		-18.454
			(2.4492)		(11.921)
Real industrial output growth(-1)			0.3200		0.1663
			(0.1392)		(0.1409)
Bonnylight oil price			0.0563**		0.2071*
			(0.0235)		(0.1019)
	PDL01	8	0.0701**	12	0.5118
			(0.0299)		(0.3138)
	PDL02		-0.0139**		-0.3048
			(0.0065)		(0.2133)
Model Diagnostics					
R^2			0.4566		0.6155
D.W.			2.0857		2.5643
AIC			5.9562		**5.8102**
SIC			**6.1251**		6.1480
Panel B: With Asymmetric oil price					
Constant			-1.2670		-8.0508
			(2.9337)		(12.655)
Real industrial output growth(-1)			0.3433**		0.1243
			(0.1382)		(0.1461)
Positive Bonnylight oil price			0.3168		0.5199**
			(0.2249)		(0.2177)
	PDL01	2	0.8537	2	1.5052**
			(0.6726)		(0.6607)
	PDL02		-0.5365		-0.9852**
			(0.4488)		(0.4448)
Negative Bonnylight oil price			0.0760***		0.0642**
			(0.0278)		(0.0312)
	PDL01	8	0.0947**	7	0.0822*
			(0.0353)		(0.0419)
	PDL02		-0.0187**		-0.0180
			(0.0077)		(0.0110)
Asymmetric test: H_0: oilp_p - oilp_n=0			0.2408		0.4557**
			(0.2274)		(0.2188)
Model Diagnostics					
R^2			0.5070		0.6425
D.W.			2.1830		2.4608
AIC			5.9589		5.8373
SIC			6.2122		6.2595

Note: This table presents the ADL-MIDAS results for the effect of crude oil price on real industrial sector output growth in Nigeria with and without control variables as well as with and without accounting for oil price asymmetry.

For parsimony, ADL MIDAS is estimated with polynomial degree (PLD/Almon) 2 (or 3 when lag 2 is not efficient). Thus, the effect of each explanatory variable is determined by the sum of the coefficients of the two polynomial degrees; PLD01 and PLD02. This is determined using Wald test. The lag length used is the optimal lag for the independent variable. Values in parenthesis indicate standard error of the corresponding coefficient. Asterisks ***, ** and * indicate statistical significance at 1%, 5% and 10% level, respectively.

Lastly, we examine the effect of crude oil price on the real service sector output growth in Nigeria. The result for this analysis using ADL-MIDAS is presented in Table 5. Evidence from Panel A shows that crude oil price has positive and statistically significant effect on the real service sector output growth in Nigeria. In other words, the higher (lower) the crude oil price, the higher (lower) the real service sector output growth. The result is stable and consistent, as it holds under the basic ADL-MIDAS models with and without control variables. The significance of asymmetric crude oil price effect is examined in Panel B. The results show evidence of asymmetric oil price effects, with the asymmetric ADL-MIDAS models with and without control variables rejecting the null hypothesis of no significant difference between the effects of positive and negative changes in oil price. This implies that asymmetry exists in the effect of crude oil price on real service sector output growth in Nigeria. Comparing the performance of the four models, the asymmetric ADL-MIDAS model with control variables appears to be the preferred model as it has the lowest AIC and SIC values. Based on the result of this optimal model, positive changes in oil price have significant negative effect on real service sector output growth but negative changes in oil price have significant positive effect on real service sector output growth.

The significant negative relationship between positive oil price and real service sector output growth implies that as oil price increases, productivity of the real sector reduces. This is possible as higher oil prices increase cost of production in the service sector, which may cause reduction in the output of the sector. On the other hand, the significant positive relationship between negative oil price and real service sector output growth implies that falling crude oil price reduces real service sector output growth in Nigeria. Falling crude oil price causing reduction in real service sector output growth may be expected, as the increase in the acceptance of public-private partnership arrangement has made some service sector operators to depend mainly on government for funding, which makes their productivity to reduce when crude oil price falls and government spending reduces. In addition, government tends to look inwards and increase taxes to the service sector when oil price falls, reducing output growth of the sector.

Table 5: Results for service sector output growth and oil price nexus in Nigeria

		Without control		With control	
Variables		**Lags**	**Coeff.**	**Lags**	**Coeff.**
Panel A: With symmetric oil price					
Constant			-2.6949***		0.3027
			(0.9762)		(5.5380)
Real service output growth(-1)			0.5618***		0.3451**
			(0.1187)		(0.1366)
Bonnylight oil price			0.1416***		0.1461***
			(0.0463)		(0.0433)
	PDL01	2	0.3749**	2	0.3891***
			(0.1402)		(0.1326)
	PDL02		-0.2333**		-0.2430**
			(0.0943)		(0.0902)
Model Diagnostics					
R^2			0.7604		0.8204
D.W.			2.1213		2.2225
AIC			4.2522		4.1640
SIC			4.4211		4.5017
Panel B: With Asymmetric oil price					
Constant			2.6700*		11.415**
			(1.4461)		(4.2427)
Real service output growth(-1)			0.4128***		0.1005
			(0.1353)		(0.1499)
Positive Bonnylight oil price			-0.0325		-0.0940**
			(0.0412)		(0.0449)
	[PDL01]	5	-0.0551	4	-0.1639**
			(0.0619)		(0.0743)
	[PDL02]		0.0226		0.0699**
			(0.0208)		(0.0295)
Negative Bonnylight oil price			0.2651***		0.3089***
			(0.0608)		(0.0578)
	[PDL01]	2	0.7333***	2	0.8805***
			(0.1805)		(0.1758)
	[PDL02]		-0.4682***		-0.5717***
			(0.1201)		(0.1185)
Asymmetric test: H_0: oilp_p - oilp_n=0			-0.2976***		-0.4029***
			(0.0794)		(0.0872)
Model Diagnostics					
R^2			0.8085		0.8821
D.W.			2.1720		2.5034
AIC			4.1280		**3.8427**
SIC			4.3814		**4.2649**

Note: This table presents the ADL-MIDAS results for the effect of crude oil price on real service sector output growth in Nigeria with and without control variables as well as with and without accounting for oil price asymmetry. For parsimony, ADL MIDAS is estimated with polynomial degree (PLD/Almon) 2 (or 3 when lag 2 is not efficient). Thus, the effect of each explanatory variable is determined by the sum of the coefficients of the two polynomial degrees;

PLD01 and PLD02. This is determined using Wald test. The lag length used is the optimal lag for the independent variable. Values in parenthesis indicate standard error of the corresponding coefficient. Asterisks ***, ** and * indicate statistical significance at 1%, 5% and 10% level, respectively.

5. Conclusion

The lack of techniques that accommodate mixed data sampling (MIDAS) frequencies in the past had restricted researchers to uniform data frequency for the purpose of empirical analyses. With the development of several variants of MIDAS regressions, the information loss associated with the use of uniform frequency can now be circumvented. Thus, the main contribution of this study is to better explore ample available oil price information in the analysis of oil price – economic growth relationship, which is likely to generate better results. Hence, this study deploys the Autoregressive Distributed Lag – Mixed Data Sampling (ADL-MIDAS) model by Ghysels et al. (2006, 2007) in analyzing the relationship. This method has been found to be very useful in explaining the determinants of economic growth in the face of mixed data frequencies (see for example, Salisu and Ogbonna, 2019). The second contribution of this study is the examination of the impact of crude oil price on real sectoral output growth, with focus on agriculture, industry and service sectors. This study provides new evidence in this respect, as earlier studies on the impact of crude oil price on output growth in Nigeria are limited to aggregate real GDP growth (see for example, Olomola and Adejumo, 2006; Akinsola and Odhiambo, 2020). The third contribution of this study is that it accounts for the role macroeconomic/control variables as well as crude oil price asymmetry. The significance of accounting for these economic properties has been appreciated in the literature (see Salisu et al., 2019), however, these have not been captured by earlier studies on the relationship between crude oil price and economic growth in Nigeria.

The result shows that accounting for crude oil price asymmetry and macroeconomic determinants increases the efficiency of the ADL-MIDAS model for the analysis of crude oil price-economic growth nexus in Nigeria. On the aggregate, the result shows that negative changes in crude oil price have positive effect on aggregate real GDP growth in Nigeria, and the effect of positive changes in crude oil price on aggregate economic growth is not significant. This suggests that falling crude oil price decreases real GDP growth significantly, and that the overall positive effect of crude oil price on economic growth observed from the model with symmetric oil price is largely due to negative changes in crude oil price.

Moreover, the result of crude oil price – agricultural sector output growth shows that no asymmetry effect exists in the relationship, as the effect of negative changes in oil price on agricultural sector output growth appears too weak to establish a significant difference from that of the positive changes in oil price. In addition, the result of the effect of crude oil price on real industrial output growth in Nigeria reveals that accounting for crude oil price asymmetry and macroeconomic variables does not matter. Based on the symmetric result, significant positive relationship is found to exist between oil price and industrial sector output growth. Similarly, the results of the effect of crude oil price on real service sector output growth in Nigeria reveal that accounting for crude oil price asymmetry and macroeconomic variables matters. The effect of negative changes in crude oil price on real service sector output growth in Nigeria is positive while that of positive changes in crude oil price on real service sector output growth in Nigeria is negative. This reveals that falling crude oil prices reduce real service sector output growth in Nigeria.

Overall, this study concludes that the impact of government participation in the economy is huge, as falling oil prices, that passed through to the economy via government revenue and finances, significantly reduce economic growth in Nigeria, with the service and industrial sectors more affected than the agricultural sector. Also, the study concludes that economic growth in Nigeria has not benefitted significantly from increases in crude oil prices; implying that government has not made effective use of the past increases in crude oil prices to create sufficient infrastructure to stimulate economic growth in Nigeria. Thus, it is recommended that government participation in the economy be reduced. The rising popularity of public-private partnership programme by government is a step in the right direction. However, we advocate further reduction in financial involvement of government in this arrangement. More importantly, our results reveal that the situation whereby recurrent to capital expenditure ratio of government is about 80/20 percent dampens the growth potential of the Nigerian economy. More investment in capital infrastructure and reduction in recurrent expenditure is recommended, to reduce the adverse effect of negative crude oil price on economic growth in Nigeria.

References

Akinsola, M. O., & Odhiambo, N. M. (2020). Asymmetric effect of oil price on economic growth: Panel analysis of low-income oil-importing countries. *Energy Reports*, *6*, 1057-1066.

Andreou, E., Ghysels, E., & Kourtellos, A. (2010). Regression models with mixed sampling frequencies. *Journal of Econometrics*, *158*(2), 246-261.

Aregbeyen, O., & Kolawole, B. O. (2015). Oil revenue, public spending and economic growth relationships in Nigeria. *Journal of Sustainable Development*, *8*(3), 113-123.

Bergmann, P. (2019). Oil price shocks and GDP growth: Do energy shares amplify causal effects?. *Energy Economics*, *80*, 1010-1040.

Bildirici, M., & Ersin, Ö. (2015). An investigation of the relationship between the biomass energy consumption, economic growth and oil prices. Procedia-Social and Behavioral Sciences, 210, 203-212.

Fasanya, I. O., & Ogundare, A. E. (2018). Trivariate analysis of oil revenue, government spending and economic growth in Nigeria. *OPEC Energy Review*, *42*(2), 107-122.

Ghysels, E., Santa-Clara, P., & Valkanov, R. (2006). Predicting volatility: getting the most out of return data sampled at different frequencies. *Journal of Econometrics*, *131*(1-2), 59-95.

Ghysels, E., Sinko, A., & Valkanov, R. (2007). MIDAS regressions: Further results and new directions. *Econometric reviews*, *26*(1), 53-90.

Ghysels, E., Santa-Clara, P., Valkanov, R. (2002). The MIDAS touch: mixed data sampling regression models. Working paper, UNC and UCLA.

Guan, L., Zhang, W. W., Ahmad, F., & Naqvi, B. (2021). The volatility of natural resource prices and its impact on the economic growth for natural resource-dependent economies: A comparison of oil and gold dependent economies. *Resources Policy*, *72*, 102125.

Gummi, U. M., Buhari, A. I., & Muhammad, A. (2017). Oil price fluctuations and economic growth in Nigeria (evidence from granger causality test). *Australasian Journal of Social Science*, *3*(1), 1-16.

Hanabusa, K. (2009). Causality relationship between the price of oil and economic growth in Japan. *Energy Policy*, *37*(5), 1953-1957.

He, Y., & Lin, B. (2018). Forecasting China's total energy demand and its structure using ADL-MIDAS model. *Energy*, *151*, 420-429.

Idrisov, G., Kazakova, M., & Polbin, A. (2015). A theoretical interpretation of the oil prices impact on economic growth in contemporary Russia. *Russian Journal of Economics*, *1*(3), 257-272.

Jawadi, F., & Ftiti, Z. (2019). Oil price collapse and challenges to economic transformation of Saudi Arabia: A time-series analysis. *Energy Economics*, *80*, 12-19.

Karagöz, K. & Ergün, S (2020). Forecasting Monthly Inflation: A MIDAS Regression Application for Turkey. Turkish Journal of Forecasting, 4(1), 1-9.

Kırca, M., Canbay, Ş., & Pirali, K. (2020). Is the relationship between oil-gas prices index and economic growth in Turkey permanent?. *Resources Policy*, *69*, 101838.

Lee, C. C., & Chiu, Y. B. (2011). Oil prices, nuclear energy consumption, and economic growth: New evidence using a heterogeneous panel analysis. *Energy Policy*, *39*(4), 2111-2120.

Maheu, J. M., Song, Y., & Yang, Q. (2020). Oil price shocks and economic growth: The volatility link. *International Journal of Forecasting*, *36*(2), 570-587.

Mensah, I. A., Sun, M., Gao, C., Omari-Sasu, A. Y., Zhu, D., Ampimah, B. C., & Quarcoo, A. (2019). Analysis on the nexus of economic growth, fossil fuel energy consumption, CO2 emissions and oil price in Africa based on a PMG panel ARDL approach. *Journal of Cleaner Production*, *228*, 161-174.

Mo, B., Chen, C., Nie, H., & Jiang, Y. (2019). Visiting effects of crude oil price on economic growth in BRICS countries: fresh evidence from wavelet-based quantile-on-quantile tests. *Energy*, *178*, 234-251.

Musa, K. S., Maijama'a, R., Shaibu, H.U. & Muhammad, A. (2019). Crude oil price and exchange rate on economic growth: ARDL approach. *Open Access Library Journal*, *6*(12), 1.

Narayan, S. (2013). Foreign exchange markets and oil prices in Asia. Journal of Asian Economics 28, 41–50.

Narayan, P.K. & Gupta, R. (2015). Has oil price predicted stock returns for over a century? Energy Econ. 48, 18–23.

Narayan, P. K., S. Narayan, & A. Prasad. (2013). Understanding the oil price-exchange rate nexus for the Fiji islands. Energy Economics 30:2686–96.

Narayan, P. K., Sharma, S., Poon, W. C., & Westerlund, J. (2014). Do oil prices predict economic growth? New global evidence. *Energy economics*, *41*, 137-146.

Olomola, P. A., & Adejumo, A. V. (2006). Oil price shock and macroeconomic activities in Nigeria. *International Research Journal of Finance and Economics*, *3*(1), 28-34.

Omitogun, O., Longe, A. E., & Muhammad, S. (2018). The impact of oil price and revenue variations on economic growth in Nigeria. *OPEC Energy Review*, *42*(4), 387-402.

Salisu, A A., Isah, K. O., Oyewole, O. J. & Akanni, L.O. (2017). Modelling oil price-inflation nexus: The role of asymmetries. *Energy*, 125(C), 97-106.

Salisu, A. A., & Ogbonna, A. E. (2019). Another look at the energy-growth nexus: New insights from MIDAS regressions. *Energy.* doi:10.1016/j.energy.2019.02.

Salisu, A. A., Swaray, R. and Oloko, T. F. (2019). Improving the predictability of the oil–US stock nexus: The role of macroeconomic variables. *Economic Modelling,* 76, 153-171.

Salisu, A.A., Cuñado, J., Isah, K. & Gupta, R. (2020). Oil Price and Exchange Rate Behaviour of the BRICS, Emerging Markets Finance and Trade, 57(7), 2042-2051.

Salisu, A.A., Ademuyiwa, I., Isah, K. (2018). Revisiting the forecasting accuracy of Phillips curve: the role of oil price. Energy Econ. 70, 334-356.

Sarwar, S., Chen, W., & Waheed, R. (2017). Electricity consumption, oil price and economic growth: Global perspective. *Renewable and Sustainable Energy Reviews*, *76*, 9-18.

Shahbaz, M., Sarwar, S., Chen, W., & Malik, M. N. (2017). Dynamics of electricity consumption, oil price and economic growth: Global perspective. *Energy Policy*, *108*, 256-270.

Smyth, R. & Narayan, P.K. (2018). What do we know about oil prices and stock returns? Int. Rev. Financ. Anal. 57, 148–156.

Salisu, A.A. & Gupta, R. (2020). How Do Housing Returns in Emerging Countries Respond to Oil Shocks? A MIDAS Touch. Emerging Markets Finance and Trade, 57(15), 4286-4311.

Van Eyden, R., Difeto, M., Gupta, R., & Wohar, M. E. (2019). Oil price volatility and economic growth: Evidence from advanced economies using more than a century's data. *Applied energy*, *233*, 612-621.

Wesseh Jr, P. K., & Lin, B. (2018). Exchange rate fluctuations, oil price shocks and economic growth in a small net-importing economy. *Energy*, *151*, 402-407.

Yazdan, G. F., Ehsan, A. G., & Hossein, S. S. M. (2012). Is cointegration between oil price and economic growth? Case study Iran. *Procedia-Social and Behavioral Sciences*, *62*, 1215-1219.

Zulfigarov, F., & Neuenkirch, M. (2020). The impact of oil price changes on selected macroeconomic indicators in Azerbaijan. *Economic Systems*, *44*(4), 100814.

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