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The Impact of Oil Price on Economic Growth in Middle-Income Oil-Importing Countries: A Non-Linear Panel ARDL Approach

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Abstract. In this study, the impact of the crude oil price on economic growth is investigated in seven middle-income oil-importing countries in sub-Saharan Africa (SSA), namely Botswana, Kenya, Mauritania, Mauritius, Namibia, South Africa, and Zambia. The estimation is based on both linear and non-linear panel autoregressive distributive lag (panel ARDL) models. The real oil price is decomposed into negative oil price shock and positive oil price shock in order to examine the non-linear impact of oil price on economic growth. Using an annual dataset from 1990 to 2018, it was found that in the symmetric model the oil price has a positive and significant impact on economic growth in the long run. The short-run estimates, however, show that the oil price has no significant impact on economic growth. The overall results from the asymmetric model also show that there is a non-linear relationship between oil price and economic growth in the studied countries.

Keywords: oil price, economic growth, middle-income countries, sub-Saharan Africa, panel asymmetric effects

JEL Classification: Q43, O55, N17, C33

1. Introduction

The debate on the impact and causal relationship of oil price and economic growth remains a subject of great interest by policymakers and researchers, especially after the drastic reduction in oil commodity prices from $105 per barrel to $47 per barrel in the second half of 2014. This connects to the fact that oil has become a major and important source of energy to the economy. Moreover, oil is an essential production input and cuts across all economic activities. It dominates the global source of energy consumption. Therefore, oil price fluctuates heavily and has both micro- and macro-economic effects on an economy. Global oil prices remained low in 2015 and increased only marginally towards the end of 2016 and at the beginning of 2017 (Canuto, 2014; Energy Information Administration, 2017).

While studies on the subject have been explored in the literature, this paper is novel in examining whether the income level of countries plays a significant role in determining the link between oil price and economic growth for oil-importing countries. Secondly, in some of the previous studies, only the causality between oil price and economic growth has been examined. The panel Autoregressive Distributive Lag (panel-ARDL) model employed in this study augments previous studies on the subject by including both the long-run and the short-run impacts (Asongu et al., 2016). Thirdly, previous studies have argued that the effect of oil price on economic growth could be non-linear. Studies that assert that oil price analysis should be nonlinear to capture the asymmetry effects include Mork (1989), Lee et al. (1995), Hooker (1996a), Jiménez-Rodríguez and Sánchez (2005), Salisu et al. (2017), and Raheem (2017). Lee et al. (1995) specifically argued that oil price volatility induces a nonlinear effect on economic activities. Hooker (1999) also affirms that the impact of oil price on growth is less accented when the data span is beyond 1973. Therefore, this study adopts the panel nonlinear Autoregressive Distributive Lag (panel-NARDL) to examine the asymmetry impact of oil price on growth. Therefore, oil price is decomposed into oil price positive and oil price negative shocks.

Lastly, many studies on this subject have mainly focused on single countries (Gbatu et al., 2017a; Benedictow et al., 2013; Aliyu, 2011; Du and Wei, 2010; Hanabusa, 2009; Mory, 1993; Hamilton, 1983; Hooker, 1996a, 1996b). Recent studies include Su et al. (2021), who examined the effect of oil price on economic uncertainty in BRICS. Jiang et al. (2021) examined the asymmetric relationship between oil price and economic uncertainty in China. The closest paper to the current study is based on work done by Akinsola and Odhiambo (2020). While Akinsola and Odhiambo (2020) focused on low-income countries, such as Mali, Mozambique, Ethiopia, Senegal, Tanzania, the Gambia, and Uganda, in the current study, the focus is on middle-importing countries such as Botswana, Kenya, Mauritius, Mauritania, Namibia, South Africa, and Zambia. As reported by some previous authors, lumping countries that are at different stages of development may lead to potential bias, which could result in inconsistent estimates (see Ghirmay, 2004; Casselli et al., 1996). Consequently, this study is aimed at only focusing on middle-income countries, as they are at the same level of economic development.

The remainder of this paper is organized as follows. Section 2 provides a global review of the literature, while Section 3 deals with the methodology, empirical model specification, and data sources. In Section 4, the empirical results are analysed and discussed, while Section 5 concludes the study and proffers policy recommendations.

2. Literature Summary

This literature review is based on the debate regarding the symmetric and asymmetric effects of oil price on economic growth. While there are huge existing studies on the subject, only a few of them have considered the nonlinear impact of oil price on economic growth using dynamic panel techniques. Hamilton (1983, 1996) was one of the pioneers of the literature on the link between oil price and economic growth. The author found that oil price exerts a negative impact on economic growth. The European Central Bank (2016) also examined the relationship between oil prices and the world GDP using simulation models from the National Institute Global Econometric Model (NiGEM), the six-mod version of IMF's flexible System of Global Models, and a structural VAR model. They reported that the growth in the aggregate demand of oil-importing countries had been limited despite the gains from lower oil prices. Therefore, a 10% decrease in oil prices driven by supply fluctuations caused an increase of between 0.1% and 0.2% in the world GDP, while a 10% decline driven by demand fluctuations caused a decrease of more than 0.2% in the world GDP. However, if the oil price declines due to more supply shocks than demand shocks, the models suggest that the combined effect of the two shocks on the world GDP would be close to zero or even slightly negative. Bacon (2005) used a large dataset in a panel study of 131 countries. Higher crude oil prices are argued to affect oil-importing countries and could be more detrimental to poorer oil-importing countries. Similarly, Rasmussen and Roitman (2011) used a global dataset in their analysis and concluded that a 25% rise in oil prices would only cause a 0.5% or lower decrease in GDP.

Time series analyses of the symmetry effect of oil price include Abeysinghe (2001), who examined the direct and indirect impact of oil price for oil-importing and oil-exporting countries. The dataset includes the US, ten Asian countries, and the OECD. The author found that higher oil prices affect both oil-importing and oil-exporting economies through direct and indirect effects. The indirect effects are from interactions with trading partners. The study concluded that even though the effect of oil price may not be significant for large economies such as the US, it nonetheless plays a critical role in small open economies. Moreover, even net oil exporters such as Indonesia and Malaysia experienced the negative impact of oil prices through a trade matrix. Another study by Kumar (2009) estimated the impact of oil price on the growth of industrial output in India using a multivariate VAR. Employing quarterly data from 1975 to 2004, Kumar (2009) found that oil price negatively impacts output growth in India. Another study on an emerging Asian country was conducted by Benedictow et al. (2013). The authors employed the general to specific OLS method to analyse the effects of oil price fluctuations on fiscal policies in Russia. They found that a higher oil price stimulates economic growth but also causes a rupture in the economy.

There is still a dearth of research on the impact of oil price on economic growth for developing countries, especially for middle-income countries in SSA. This may be because the demand for energy and oil in developing countries has been growing only in recent times. Some studies based on SSA, such as Fofana et al. (2009) and Ziramba (2010), examined the relationship between oil prices and the South African economy. Using the Computable General Equilibrium (CGE) Model and the Macro-Meso-Micro modelling approach, the study found that oil price negatively impacts the macro-economy of South Africa, especially its GDP and current account. Other studies on South Africa include those conducted by McDonald and van Schoor (2005) and Essama-Nssah et al. (2007), who also used the CGE Model. McDonald and van Schoor (2005), for example, found that a 20% increase in oil prices results in a 1% decrease in GDP. Major impacts were in the petroleum industry, but the effect on a "liquid-fuel"-dependent sector, such as transport, is not as large as expected. The depreciating currency was found to offset the negative impact of higher petroleum prices, especially in exporting areas of the sector. In the long run, there is a high mobility of capital and skilled labour, which may not be advantageous to the whole economy.

Essama-Nssah et al. (2007) examined the economy-wide and distributional impact of oil price shocks on South Africa. The authors employed a CGE macro to the micro-framework. Their CGE Model had 43 production activities categorized into agriculture, industry, and services. The study found that a surge in the crude oil price results in a reduction in the quantity of imported crude oil by approximately 1%. The micro results showed the welfare impact of the oil price shock on the level of skills of households.

Some studies have examined the asymmetric effect of oil prices on macro-economy. Gbatu et al. (2017a) found the presence of asymmetries using asymptotic and bootstrap distribution techniques for an oil-importing country, namely Liberia. Positive oil price shocks are found to have a positive impact on the Liberian economy. Balcilar et al. (2017) also found the presence of a nonlinear relationship between oil price and economic growth. The authors employed growth regime analysis in a Markov switching VAR and found that oil price is predictive of real output growth, especially in low-growth regimes. They found that the high-growth regime is longer on average than the period of the low-growth regime.

Other studies that have examined the asymmetric effect of oil price using an ARDL methodology include those conducted by Nusair (2016), Salisu et al. (2017), and Raheem (2017). Salisu et al. (2017) employed panel linear and nonlinear ARDL techniques and investigated the impact of oil price on inflation in a panel of oil-importing and oil-exporting countries. They found that the effect of asymmetries in the oil price seems to be higher in the panel of oil-exporting countries. Raheem (2017) also found an asymmetric effect of oil price on trade components for six countries in a time series analysis. The countries are categorized into oil-importing, oil-exporting, and high-trading countries.

3. Empirical Model Specification, Methodology, and Data Sources

3.1. Empirical Model Specification and Methodology

A modified version of Gbatu et al's (2017b) model is used in this study to examine the linear and nonlinear impact of oil price on economic growth in seven middle-income SSA countries. The model is extended by including oil consumption, labour force, investment, and domestic credit as a percentage of GDP.

The model can be expressed as follows:

$$y = f(ROP, OC, LF, INV, RER, DC) \tag{1}$$

Real GDP per capita is represented as y and presented as a function of the real oil price, oil consumption labour force participation rate, investment, real exchange rate, and domestic credit as a percentage of GDP. All variables are expressed in logarithmic form.

A dynamic model based on Pesaran et al. (1999) is presented as a panel ARDL (p,q) to estimate the long-run and the short-run relationship among the variables. Therefore, the panel ARDL model is specified as follows:

$$\begin{aligned}\Delta y_{it} = \lambda_i &+ \sum_{j=1}^{p} \lambda_{1ij}\, \Delta y_{i,t-j} + \sum_{j=0}^{q} \lambda_{2ij}\, \Delta ROP_{i,t-j} + \sum_{j=0}^{q} \lambda_{3ij}\, \Delta OC_{i,t-j} + \sum_{j=0}^{q} \lambda_{4ij}\, \Delta LF_{i,t-j} \\ &+ \sum_{j=0}^{q} \lambda_{5ij}\, \Delta INV_{i,t-j} \sum_{j=0}^{q} \lambda_{6ij}\, \Delta REER_{i,t-j} + \sum_{j=0}^{q} \lambda_{7ij}\, \Delta DC_{i,t-j} + \delta_{1ij} \Delta y_{i,t-1} \\ &+ \delta_{2ij} \Delta ROP_{i,t-1} + \delta_{3ij} \Delta OC_{i,t-1} + \delta_{4ij} \Delta LF_{i,t-1} + \delta_{5ij} \Delta INV_{i,t-1} \\ &+ \delta_{6ij} \Delta REER_{i,t-1} + \delta_{7ij} \Delta DC_{i,t-1} + \varepsilon_{it},\end{aligned} \tag{2}$$

where y_{it} is the dependent variable for group i. The groups are denoted as i = 1,2,… N countries, and t = 1,2… T periods. λ_i represents the fixed effects. The first part of the model with coefficients λ_1 *to* λ_7 depicts the short-run dynamics of the model, and the second part with coefficients δ_1 *to* δ_7 depicts the long-run relationship and the error term.

After establishing a long-run relationship, the panel error correction model (ECM) is presented as follows:

$$\Delta y_{it} = \lambda_i + \sum_{j=1}^{p} \lambda_{1ij}\, \Delta y_{i,t-j} + \sum_{j=0}^{q} \lambda_{2ij}\, \Delta ROP_{i,t-j} + \sum_{j=0}^{q} \lambda_{3ij}\, \Delta OC_{i,t-j} + \sum_{j=0}^{q} \lambda_{4ij}\, \Delta LF_{i,t-j}$$

$$+ \sum_{j=0}^{q} \lambda_{5ij}\, \Delta INV_{i,t-j} + \sum_{j=0}^{q} \lambda_{6ij}\, \Delta REER_{i,t-j} + \sum_{j=0}^{q} \lambda_{7ij}\, \Delta DC_{i,t-j} + \lambda_{8ij} ECT$$

$$+ \varepsilon_{it} \tag{3}$$

The asymmetric effect of oil price on growth is also examined in a panel nonlinear ARDL (panel NARDL) model. The panel NARDL model used in capturing the asymmetric impact follows Shin et al. (2014) and is specified as follows (see Raheem, 2017; Salisu et al., 2017):

$$\Delta y_{it} = \phi_i\left(y_{i,t-1} + ROP^{+}_{i,t-1} + ROP^{-}_{i,t-1} + \gamma'_i X_{i,t}\right) + \sum_{j=1}^{p-1} \lambda^{*}{}_{ij}\, y_{i,t-j} + \sum_{j=1}^{q-1} \lambda^{*}{}_{ij}\, ROP^{+}_{i,t-j}$$
$$+ \sum_{j=1}^{p-1} \lambda^{*}{}_{ij}\, ROP^{-}_{i,t-j} + \sum_{j=0}^{q-1} \sigma^{*}{}_{ij}\, X_{i,t-j} + \mu_i + \varepsilon_{it}, \tag{4}$$

where ROP^{+} and ROP^{-} depict decomposed oil price into oil price positive and negative changes respectively. The oil price can be theoretically decomposed as (see Raheem, 2017):

$$ROP^{+}_{i,t} = \sum_{j=1}^{t} \Delta\, ROP^{+}_{i,j} = \sum_{j=1} \max\,(\Delta\, ROP^{+}_{i,j}, 0) \tag{5}$$

$$ROP^{-}_{i,t} = \sum_{j=1}^{t} \Delta\, ROP^{-}_{i,j} = \sum_{j=1} \min\,(\Delta\, ROP^{-}_{i,j}, 0) \tag{6}$$

Equation (6) can be re-parameterized to include the ECM as follows (see Salisu et al., 2017):

$$\Delta y_{it} = \tau_i\, \xi_{i,t-1} + \sum_{j=1}^{N1} \lambda_{ij}\, \Delta y_{i,t-j} + \sum_{j=0}^{N2} (\,\gamma^{+}_{ij}\, \Delta ROP^{+}_{t-j} + \gamma^{-}_{ij}\, \Delta ROP^{-}_{t-j}) + \mu_i + \varepsilon_{it} \tag{7}$$

The error correction term ($\xi_{i,\,t-1}$) captures the long-run equilibrium in the panel-NARDL, while τ_i represents the speed of adjustment that measures the time frame it takes the system to converge to its long-run equilibrium during a shock.

3.2 Data Sources

The countries included in this study are Botswana, Kenya, Mauritius, Mauritania, Namibia, South Africa, and Zambia. Brent crude oil price has been chosen as it has been found to be a major measure of crude oil price in the world. The data on real GDP per capita, investment, labour force participation rate, and domestic credit were obtained from the World Development Indicators, while data on the oil price was obtained from the BP Statistical Review of World Energy. Data on oil consumption were sourced from Energy Information Administration, while the real exchange rate was obtained from the Bruegel Statistical database.

4. Empirical Analysis

4.1 Panel Unit Root Tests

The panel unit root test is conducted using the homogenous unit root process (Levin, Lin, and Chu – hereafter as LLC and the Breitung tests) and the heterogeneous unit root process (Im, Perasan, and Shin Chu – hereafter as IPS, ADF-Fisher, and PP-Fisher Chi-square tests). The homogenous unit root process assumes that a common unit root process exists in the panel. This assumption that the unit root processes are homogenous across cross-sections might be restrictive since the literature shows that the economic structure and oil consumption of the sampled countries are heterogeneous. Therefore, they respond differently to oil price changes. This heterogeneity was also acknowledged by Behmiri and Manso (2013) and Salisu and Isah (2017).

The heterogeneous panel unit root tests, however, allow heterogeneity across cross-sections and relax the assumption that all panels share the same autoregressive parameter. The null hypothesis for these tests is that there is a unit root for all cross-sections, and the alternative hypothesis is that some cross-sections are stationary (Barbieri, 2006). *Table 1* presents the results from the panel unit root tests.

The results from *Table 1* show that some of the variables are stationary at level, while others are stationary at first difference. The results of the panel unit root tests confirm the suitability of the panel ARDL model, which allows for the combination of I(0) and I(1) order of integration (Salisu and Isah, 2017).

Table 1. *Panel unit root tests*

Variable	Tests	At level		At first difference		Order of integration
		Intercept	Trend	Intercept	Trend	
y	LLC	0.04(0.518)	-0.91(0.180)	-6.02***(0.000)	-5.77***(0.000)	
	Breitung	-	1.27(0.898)	-	-2.88***(0.002)	
	IPS	3.63(1.000)	-1.50*(0.067)	-6.70***(0.000)	-5.61***(0.000)	I(1)
	ADF-Fisher	1.95(1.000)	21.87*(0.081)	70.95***(0.000)	57.51***(0.000)	
	PP-Fisher	1.19(1.000)	21.04(0.101)	105.25***(0.000)	332.48***(0.000)	
ROP	LLC	-5.13***(0.000)	2.18**(0.015)	-	-	
	Breitung	-	-0.33(0.373)	-	-4.18***(0.000)	
	IPS	-3.89***(0.000)	-2.00**(0.023)	-	-	I(0)
	ADF-Fisher	42.19***(0.000)	24.09**(0.045)	-	-	
	PP-Fisher	42.75***(0.000)	21.88**(0.047)	-	-	
OC	LLC	-0.84(0.200)	-3.73***(0.000)	-6.93***(0.000)	-	
	Breitung	-	-1.44*(0.075)	-	-	
	IPS	1.31(0.904)	-4.26***(0.000)	-9.78***(0.000)	-	I(1)
	ADF-Fisher	8.68(0.851)	46.58***(0.000)	106.12***(0.000)	-	
	PP-Fisher	17.81(0.216)	45.63***(0.000)	163.20***(0.000)	-	
RER	LLC	-1.16(0.123)	-1.07(0.142)	-7.10***(0.000)	-5.97***(0.000)	
	Breitung	-	-1.64**(0.051)	-	-6.46***(0.000)	
	IPS	-0.05(0.479)	-0.65(0.257)	-7.61***(0.000)	-6.58***(0.000)	I(1)
	ADF-Fisher	14.92(0.384)	17.28(0.242)	80.42***(0.000)	65.41***(0.000)	
	PP-Fisher	10.06(0.758)	13.37(0.498)	124.12***(0.000)	338.24***(0.000)	
INV	LLC	-1.98**(0.024)	-1.80**(0.036)	-	-	
	Breitung	-	-3.19***(0.000)	-	-	
	IPS	-1.93**(0.027)	-2.69***(0.004)	-	-	I(0)
	ADF-Fisher	23.12**(0.058)	29.31***(0.009)	-	-	
	PP-Fisher	22.36*(0.071)	23.76**(0.049)	-	-	

Variable	Tests	At level		At first difference		Order of integration
		Intercept	Trend	Intercept	Trend	
LF	LLC	1.27(0.899)	0.08(0.530)	-3.43***(0.000)	-2.83***(0.002)	
	Breitung	-	-1.35*(0.089)	-	-3.51***(0.000)	
	IPS	3.56(1.000)	-2.27**(0.012)	-4.62***(0.000)	-3.30***(0.000)	I(1)
	ADF-Fisher	4.14(0.995)	26.22**(0.024)	52.46***(0.000)	39.54***(0.000)	
	PP-Fisher	9.03(0.829)	9.37(0.807)	52.18***(0.000)	39.19***(0.000)	
DC	LLC	-5.31***(0.000)	0.07(0.528)	-	-9.05***(0.000)	
	Breitung	-	-1.62**(0.053)	-	-	
	IPS	-4.84***(0.000)	-3.23***(0.001)	-	-	I(0)
	ADF-Fisher	55.81***(0.000)	34.39***(0.002)	-	-	
	PP-Fisher	46.12***(0.000)	34.62***(0.002)	-	-	

*Notes: Probability values in parentheses. ***, **, and * imply statistical significance at 1%, 5%, and 10% levels respectively. LLC stands for Levin, Lin, and Chu test, IPS is the Im, Pesaran, and Shin test, ADF is the augmented Dickey–Fuller test, and PP is the Phillips–Perron test.*

4.2 Panel Cointegration Tests

This study employs the Pedroni (2004) and Kao (1999) panel cointegration tests to examine the cointegration relationship between oil price and its regressors. The results of these tests are reported in *tables 2–3*.

Table 2. *Pedroni cointegration test*

	Statistic	**P-value**	**Weighted statistic**	**P-value**
Within-dimension				
Panel v-Statistic	4.781***	0.000	2.388***	0.009
Panel rho-Statistic	3.063	0.999	3.037	0.999
Panel PP-Statistic	0.400	0.656	0.567	0.715
Panel ADF-Statistic	-1.296*	0.098	-1.284	0.100
Between-dimension				
Group rho-Statistic	3.567		1.000	
Group PP-Statistic	-3.415***		0.000	
Group ADF-Statistic	-3.088***		0.001	

*Notes: *** and * indicate statistical significance at 1% and 10% levels respectively.*

The results reported in *Table 2* show that four out of seven tests reject the null hypothesis of no cointegration in the Pedroni test. These four statistics are panel v, panel ADF, group PP, and group ADF statistics. The panel v, group PP, and group ADF statistics are significant at the 1% level, while the panel ADF statistics are significant at the 10% level. Therefore, the results of the Pedroni test confirm the presence of a cointegrating relationship among the variables. Similarly, the cointegration test was conducted using the Kao panel cointegration test. The result with a -2.262 statistic and 0.012 probability value rejects the null hypothesis of no cointegration at the 5% level of significance. Hence, both panel cointegration tests confirm the existence of a long-run relationship among the variables used in this study.

4.3 Symmetry Effect of Oil Price

The results of the panel unit root tests and panel cointegration tests show that we can now proceed with the panel ARDL estimation. The results of the linear impact of oil price on economic growth based on panel ARDL are reported in *Table 3*.

The Hausman test values of 3.16 and its probability of 0.789 suggest that it is not significant. Therefore, the null hypotheses that the difference in coefficients is not systematic are rejected and confirm that the difference is systematic, thereby confirming that the PMG is more appropriate than the MG at 5%. The results for the long-run estimates reported in *Table 4* show that the real oil price exerts a positive and significant impact on growth. Although contrary to the expectations of this study, this finding is in line with studies conducted by Behmiri and Manso (2013) and Suleiman (2013), amongst others. Behmiri and Manso (2013), for example, found a positive impact of oil price on economic growth for some of the countries in the panel of oil-importing countries. Suleiman (2013) also reported that oil price positively impacts economic growth. The study included South Africa – one of the countries which are also included in the current sample. The variables are, however, not significant in the short-run country estimates. The error correction term conforms to a priori expectation; it is negative and significant, which signifies that the speed of adjustment is high.

Table 3. *Symmetric PMG estimates*

Dependent variable: y				
Panel PMG long-run estimates				
Regressors	Coefficient	Std. error	t-statistic	P-value
ROP	0.076***	0.010	7.948	0.000
OC	0.014	0.030	0.477	0.634
LF	-0.009	0.205	-0.045	0.964
INV	0.087***	0.031	2.805	0.006
DC	0.015	0.029	0.511	0.610
RER	-0.052	0.037	-1.410	0.161
Panel PMG short-run estimates				
Constant	2.532***	0.643	3.937	0.000
D(ROP)	0.003	0.008	0.427	0.670
D(OC)	0.030	0.025	1.196	0.234
D(LF)	-0.897	0.934	-0.961	0.338
D(INV)	-0.010	0.018	-0.522	0.602
D(DC)	0.000	0.019	0.025	0.980
D(RER)	0.005	0.020	0.258	0.797
ECT	-0.343***	0.081	-4.225	0.000
Hausman test	3.16(0.789)			
Akaike info criterion	-4.546			
Schwarz criterion	-3.420			
S. E. of regression	0.023			

*Notes: *** indicates statistical significance at 1% level.*

Moreover, innovation in the use of oil enhances productivity, and, therefore, oil consumption efficiently employed with modern innovation may have a positive impact on economic growth (Berk and Yetkiner, 2014). The result is also in line with the mainstream theory of economic growth (see: Estrada and Hernandez de Cos, 2012; Berk and Yetkiner 2014), which deliberates on the capacity of energy in the production process, especially for oil-importing countries. The results of the short-run country estimates are reported in *Table 4*.

Table 4. *Short-run country estimates for the symmetric effect of oil price*

	Botswana	Kenya	Mauritania	Mauritius	Namibia	South Africa	Zambia
Constant	2.850 (0.195)	0.169 (0.195)	3.150** (0.017)	0.687** (0.026)	3.909* (0.059)	5.277** (0.031)	2.399** (0.035)
D(ROP)	0.037*** (0.000)	0.011*** (0.000)	0.017*** (0.000)	-0.011*** (0.000)	-0.008*** (0.000)	0.0004* (0.099)	-0.023*** (0.000)
D(OC)	0.037** (0.007)	0.018*** (0.000)	0.018*** (0.000)	0.130*** (0.000)	-0.061*** (0.000)	0.101*** (0.000)	-0.029*** (0.001)
D(LF)	0.062 (0.485)	0.244* (0.083)	0.665 (0.735)	-0.668*** (0.003)	-0.062 (0.712)	-0.097 (0.173)	-6.425 (0.134)
D(INV)	-0.060*** (0.002)	0.044*** (0.000)	-0.069*** (0.000)	-0.008*** (0.001)	-0.023*** (0.001)	0.061*** (0.000)	-0.010*** (0.002)
D(DC)	-0.005*** (0.000)	-0.026*** (0.000)	-0.064*** (0.000)	0.043*** (0.000)	0.076*** (0.000)	0.019*** (0.002)	-0.041*** (0.000)
D(RER)	-0.092 (0.119)	0.013** (0.009)	0.011 (0.203)	0.076*** (0.000)	-0.032** (0.008)	0.023*** (0.000)	0.037*** (0.001)
ECT	-0.357*** (0.001)	-0.028*** (0.001)	-0.458*** (0.000)	-0.081*** (0.000)	-0.484*** (0.000)	-0.618*** (0.000)	-0.379*** (0.000)

*Notes: Probability values in parentheses. ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels respectively.*

The results show that there is a negative and significant effect of the real oil price on economic growth in Mauritius, Namibia, and Zambia. This has been confirmed by the coefficients of the real oil price, which are negative and statistically significant in these countries. Unlike in the case of these three countries, the results show that there is a positive impact of real oil price on economic growth in Botswana, Kenya, Mauritania, and South Africa. This finding has been confirmed by the coefficients of the real oil price in these countries, which are positive and statistically significant. A possible explanation for this positive relationship between oil price and economic growth may be associated with the inclusion of South Africa, which imports crude oil and exports refined oil to other African countries, despite their high level of oil consumption. Other countries, such as Kenya, are also currently developing their crude oil production (Kibunyi et al., 2018). Moreover, Hooker (1996) argues that the impact of oil price on economic growth is not serious for data following 1980.

Furthermore, the coefficients of error correction terms (ECTs) for all countries are significant and negative except for South Africa, which implies a quick correction to the steady state for all countries. The coefficients of the ECTs show that the speed of adjustment to the equilibrium is high and is corrected in the next period.

4.4 Asymmetry Effect of Oil Price

The asymmetry effect of oil price on economic growth is presented in *tables 5–6*. *Table 5* presents the long-run and short-run estimates of the nonlinear (asymmetry) effect of oil price changes, while *Table 6* provides an overview of the short-run country estimates.

Table 5. *Asymmetric PMG estimates*

Dependent variable: y				
Panel PMG long-run estimates				
Regressors	Coefficient	Std. error	t-statistic	P-value
ROP^{-}	0.162***	0.030	5.358	0.000
ROP^{+}	-0.166***	0.047	-3.535	0.001
OC	0.002	0.038	0.046	0.963
LF	0.499**	0.212	2.351	0.021
INV	0.086***	0.028	3.072	0.003
DC	0.011	0.018	0.617	0.539
RER	0.224***	0.065	3.463	0.001
Panel PMG short-run estimates				
Constant	1.381**	0.532	2.595	0.011
D(y(-1))	-0.042	0.079	-0.536	0.593
D(y(-2))	-0.063	0.145	-0.432	0.666
D(ROP^{-})	-0.002	0.017	-0.136	0.892
D(ROP^{+})	0.040***	0.013	3.066	0.003
D(OC)	0.045**	0.020	2.240	0.027
D(LF)	-0.953	0.691	-1.380	0.170
D(INV)	-0.022	0.016	-1.346	0.181
D(DC)	-0.023	0.030	-0.773	0.441
D(RER)	-0.011	0.039	-0.271	0.787
ECT	-0.324***	0.113	-2.858	0.005
Hausman test	6.85(0.125)			
Akaike info criterion	-4.354			
Schwarz criterion	-2.869			
S. E. of regression	0.019			

*Notes: *** and ** indicate statistical significance at 1% and 5% levels respectively.*

The real oil price is decomposed into positive real oil price shocks and negative real oil price shocks to capture the asymmetry effect of the real oil price. The Hausman test values of 6.85 and its probability of 0.125 confirms that the PMG is more appropriate than the MG at 5%. Findings from the long-run estimates show that a negative oil price shock has a positive impact on economic growth, while a positive oil price shock has a negative impact on economic growth. The results are in line with the expected results for oil-importing countries. However, in the short run, a positive change in the real oil price has a positive impact on economic growth, while a negative shock in the real oil price does not significantly impact growth. The short-run country estimates for the asymmetric model are reported in *Table 6*.

Table 6. *Short-run country estimates for asymmetry effect of oil price*

	Botswana	Kenya	Mauritania	Mauritius	Namibia	South Africa	Zambia
Constant	0.034*** (0.000)	-0.040 (0.379)	-0.089*** (0.004)	0.046** (0.013)	-0.042 (0.794)	-0.014*** (0.000)	-0.395*** (0.001)
D(y(-1))	-0.204** (0.013)	-0.275*** (0.000)	0.132* (0.083)	-0.307*** (0.000)	0.271*** (0.000)	0.340** (0.016)	-0.435*** (0.000)
D(y(-2))	0.235** (0.007)	-1.115*** (0.000)	-0.341*** (0.000)	-0.496*** (0.001)	0.173*** (0.001)	0.249*** (0.001)	-0.125*** (0.000)
D(ROP^{-})	0.158*** (0.000)	0.007*** (0.000)	0.044*** (0.000)	-0.034*** (0.000)	0.015*** (0.001)	0.044*** (0.000)	-0.007*** (0.000)
D(ROP^{-} (-1))	-0.037*** (0.000)	0.044*** (0.000)	0.005*** (0.000)	0.013*** (0.000)	-0.052*** (0.000)	-0.024*** (0.000)	0.039*** (0.000)
D(ROP^{+})	-0.064*** (0.001)	0.036*** (0.000)	0.026*** (0.000)	-0.021*** (0.000)	0.027*** (0.000)	0.040*** (0.000)	0.007** (0.021)
D(ROP^{+} (-1))	-0.094*** (0.000)	-0.017*** (0.000)	-0.144*** (0.000)	0.044*** (0.001)	0.026** (0.008)	0.007*** (0.000)	-0.125*** (0.000)
D(OC)	0.092*** (0.000)	0.001 (0.245)	-0.008*** (0.002)	0.104*** (0.000)	-0.051*** (0.000)	-0.014*** (0.000)	0.056*** (0.000)
D(OC(-1))	-0.069*** (0.000)	0.046*** (0.000)	0.022*** (0.000)	-0.075** (0.020)	0.005 (0.275)	-0.155*** (0.000)	0.070*** (0.000)
D(LF)	0.771*** (0.003)	0.814** (0.025)	-5.785 (0.628)	-0.209*** (0.004)	-0.296*** (0.000)	0.593*** (0.000)	-3.911* (0.058)
D(LF(-1))	0.071 (0.965)	0.023 (0.357)	6.489 (0.519)	-0.473*** (0.000)	0.195 (0.310)	0.055 (0.342)	-6.720 (0.706)
D(INV)	-0.008* (0.070)	-0.012*** ((0.000)	-0.026*** (0.000)	0.019*** (0.000)	0.054*** (0.000)	0.038*** (0.000)	0.006*** (0.000)
D(INV(-1))	0.009* (0.089)	-0.009*** (0.000)	0.024*** (0.001)	0.028*** (0.000)	0.046*** (0.000)	-0.008*** (0.000)	0.002 (0.119)
D(DC)	-0.002*** (0.000)	-0.111*** (0.000)	-0.176*** (0.000)	0.014*** (0.000)	-0.296*** (0.000)	0.002*** (0.000)	-0.116*** (0.000)
D(DC(-1))	0.004*** (0.003)	0.022*** (0.000)	-0.045*** (0.000)	-0.014*** (0.000)	0.009*** (0.000)	-0.029*** (0.000)	-0.045*** (0.000)
D(RER)	-0.053 (0.268)	0.225*** (0.000)	0.453*** (0.003)	0.190*** (0.000)	0.127*** (0.000)	0.003*** (0.000)	-0.046*** (0.000)
D(RER(-1))	-0.513*** (0.004)	0.120*** (0.000)	0.254** (0.012)	-0.073*** (0.001)	0.228*** (0.000)	0.020*** (0.001)	-0.084*** (0.000)
ECT	0.066** (0.015)	0.002*** (0.001)	-0.118*** (0.000)	-0.095*** (0.000)	-0.586*** (0.000)	0.075*** (0.000)	-0.197*** (0.000)

*Notes: Probability values in parentheses. ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels respectively.*

The ECTs are negative and significant in four of the seven countries. The decomposed oil price changes have mixed effects in the countries. The result showed that the real oil price positive shock exerts a negative impact on growth in two countries, while the real oil price negative shock positively impacts growth in five countries. Therefore, the positive effect of a negative shock in the real oil price is more evident in the panel of countries. This implies that most of the countries have the potential for growth in real GDP due to savings from negative price shocks. Oil price shocks can affect monetary, fiscal, and structural policies depending on whether a country is an oil importer or exporter. Therefore, when the oil price is very low, the selected SSA oil importers can encourage loose monetary policies and forward-looking policies that will accentuate stable macroeconomic policies. Lower oil prices can generate significant savings that will help improve most oil-importing countries' structural and fiscal position and enhance economic growth in the short and long run. This finding is different from Jiang et al. (2021), who examined the asymmetric and volatility relationship of global oil prices and economic uncertainty in China. They found that the effect of oil price is greater during monetary policy uncertainty than during fiscal policy uncertainty. Negative oil price shocks have a negative effect on monetary policy uncertainty in the short to medium term. It, however, changes to positive impact in the medium to long term. However, Su et al. (2021) also found that negative oil price shock has an impact on economic policy uncertainty in Russia and South Africa.

4.5 Diagnostic Tests

Findings from the cross-sectional dependence (CD) tests are presented in *Table 7*. The CD tests are important for panel data analysis. Panel data analysis tends to exhibit cross-sectional dependence due to unexplained components in the residual terms and the presence of common shocks (Eregha and Mesagan, 2020). The cross-sectional dependence tests presented here include the Breusch–Pagan Lagrange Multiplier (LM) test, the Pesaran Lagrange Multiplier (LM) normality test, the Pesaran Cross-Sectional Dependence (CD) test, the Friedman Chi-square test, and the Frees normality test.

Evidence in *Table 7* suggests that the null hypothesis of cross-sectional dependence can be rejected, as most of the tests are not significant in both the symmetry and asymmetry models. This implies that there is no major cross-sectional reliance among the selected oil-importing middle-income countries. Only the Pesaran LM test is significant at the 5% level in the asymmetry model. However, because of the role that regional cooperation plays in international trade among its members, the Pesaran LM test conclusion implies that a certain level of dependency may exist. However, such a relationship is not strong enough to imply a strong cross-sectional dependence. The results of cross-dependence tests, therefore, validate the use of the first-generation unit root tests as appropriate for the panel of MICs in this study.

Table 7. *Panel cross-sectional dependence test*

	Symmetry			Asymmetry		
Test	Statistic	P-value		Statistic	P-value	
Breusch–Pagan LM	28.400	0.129		13.116	0.905	
Pesaran LM	0.062	0.951		-2.297**	0.022	
Pesaran CD	-0.749	0.454		0.491	0.624	
Friedman	23.392	0.713		27.800	0.475	
Frees Q	0.021	1%	0.166	-0.079	1%	0.166
		5%	0.116		5%	0.116
		10%	0.089*		10%	0.089*

*Notes: ** and * indicate statistical significance at 5% and 10% levels respectively.*

5. Conclusions

In this paper, the impact of oil price on economic growth is examined using data from seven SSA middle-income countries. The study adopted linear and nonlinear panel ARDL techniques to examine the oil price growth dynamics. The study is based on oil-importing countries, which include Botswana, Kenya, Mauritania, Mauritius, Namibia, South Africa, and Zambia. The results of the linear panel ARDL show that real oil price has a positive impact on economic growth. However, the positive effect of the oil price on economic growth in the model might be due to the influence of large economies such as South Africa, which imports crude oil and exports refined oil products. Moreover, middle-income countries are characterized by more efficient use of energy unlike low-income countries that put pressure on the economic stance of low-income countries. However, oil price does not significantly impact economic growth for the PMG estimates in the short run. The short-run country estimates show that oil price negatively impacts economic growth in three of the seven countries.

The results of the asymmetric panel ARDL show that both forms of oil price shocks have a significant effect on growth in the long run. Real oil price positive shock has a negative impact on economic growth, while real oil price negative shock has a positive impact on economic growth, which is consistent with the a priori expectations. In the short run, contrary to the expected results, a positive oil price shock has a positive effect on economic growth, while a negative oil price shock does not have a significant impact on economic growth. Oil consumption also has a positive and significant impact on growth in the short run. Findings from the short-run country estimates are in line with the expected result in some of the countries. The negative oil price shock has a positive impact on economic growth in five countries, while the positive oil price shock has a negative impact on economic growth in two of the seven countries.

Overall, the results show that the impact of oil price on economic growth in middle-income oil-importing countries depends on whether the model is linear or nonlinear. It is, therefore, imperative for MICs' policymakers to adopt technological advancement to explore growth from oil, especially during periods of lower oil prices since negative oil price shocks have a positive impact on economic growth in five of the seven countries, and oil consumption positively impacts growth in the short run. The negative impact of oil price positive shock in only two countries might be because countries in the panel of MIC utilize other sources of energy such as coal and renewable energy. Moreover, the studied countries could also adopt market-friendly energy price controls and diversification of energy sources in order to reduce the risks resulting from oil price fluctuations.

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References

Abeysinghe, T. (2001). Estimation of direct and indirect impact of oil price on growth. *Economics Letters* 73(2): 147–153.

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.

Aliyu, S. U. (2011). Oil price shocks and the macroeconomy of Nigeria: A non-linear approach. *Journal for International Business and Entrepreneurship Development* 5(3): 179–198.

Amusa, H.; Wabiri, N.; Chetty, K. (2008). Application of a multi-criteria integrated portfolio model for quantifying South Africa's crude oil import risk. *Working Paper No. 108*, *Economic Research Southern Africa*.

Asongu, S.; El Montasser, G; Toumi, H. (2016). Testing the relationships between energy consumption, CO_2 emissions, and economic growth in 24 African countries: A panel ARDL approach. *Environmental Science and Pollution Research* 23(7): 6563–6573.

Bacon, R.; Mattar, A. (2005). The vulnerability of African countries to oil price shocks: Major factors and policy options. *ESMAP. Report* 308/5.

Balcilar, M.; Van Eyden, R.; Uwilingiye, J.; Gupta, R. (2017). The impact of oil price on South African GDP growth: A Bayesian Markov switching VAR analysis. *African Development Review* 29(2): 319–336.

Barbieri, L. (2006). Panel unit root tests: A review. *SerieRossa: Economia-UCSC Piacenza* 43: 1–53.

Behmiri, N.; Manso, J. (2013). How crude oil consumption impacts on economic growth of sub-Saharan Africa? *Energy* 54: 74–83.

Benedictow, A.; Fjærtoft, D.; Løfsnæs, O. (2013). Oil dependency of the Russian economy: An econometric analysis. *Economic Modelling* 32: 400–428.

Berk I.; Yetkiner H. (2014). Energy prices and economic growth in the long run: Theory and evidence. *Renewable and Sustainable Energy Reviews* 36: 228–235.

Bjørnland, H. C. (2000). The dynamic effects of aggregate demand, supply and oil price shocks—A comparative study. *The Manchester School* 68(5): 578–607.

BP (2018). *Statistical Review of World Energy*. 67th edition.

Canuto, O. (2014). The commodity super cycle: Is this time different? *Economic Premise* 150: 1–3.

Casselli, F.; Esquivel, G.; Lefort, F. (1996). Reopening the convergence debate: A new look at cross-country growth empirics. *Journal of Economic Growth* 1(3): 363–389.

Du, L.; Wei, C. (2010). The relationship between oil price shocks and China's macroeconomy: An empirical analysis. *Energy Policy* 38: 4142–4151.

Eregha, P. B.; Mesagan, E. P. (2020). Oil resources, deficit financing and per capita GDP growth in selected oil-rich African nations: A dynamic heterogeneous panel approach. *Resources Policy* 66: 1–11.

Essama-Nssah, B.; Go, D. S.; Kearney, M.; Korman, V.; Robinson, S.; Thierfelder, K. (2007). *Economy-wide and distributional impacts of an oil price shock on the South African economy*. The World Bank.

Estrada, A.; Hernández de Cos, P. (2012). Oil prices and their effect on potential output. *Applied Economics Letters* 19(3): 207–214.

European Central Bank (2016). *Economic Bulletin*. Retrieved from: https://www.ecb.europa.eu/pub/pdf/ecbu/eb201603.en.pdf.

Fofana, I.; Chitiga, M.; Mabugu, R. (2009). Oil prices and the South African economy: A macro-meso-micro analysis. *Energy policy* 37(12): 5509–5518.

Gbatu, A. P.; Wang, Z.; Wesseh, P. K., Jr.; Tutdel, I. Y. R. (2017a). The impacts of oil price shocks on small oil-importing economies: Time series evidence for Liberia. *Energy* 139: 975–990.

(2017b). Asymmetric and dynamic effects of oil price shocks and exchange rate fluctuations: Evidence from a panel of Economic Community of West African States (ECOWAS). *International Journal of Energy Economics and Policy* 7(3): 1–13.

Ghirmay, T. (2004). Financial development and economic growth in sub-Saharan African countries: Evidence from time series analysis. *African Development Review* 16(3): 415–432.

Hamilton, J. D. (1983). Oil and the macroeconomy since World War II. *Journal of Political Economy* 91(2): 228–248.

(1996). This is what happened to the oil price – macroeconomy relationship. *Journal of Monetary Economics* 38: 215–220.

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

Hooker, M. A. (1996a). What happened to the oil price macroeconomics relationship? *Journal of Monetary Economics* 38: 195–213.

(1996b). This is what happened in the oil price macroeconomics relationship: Reply. *Journal of Monetary Economics* 38: 221–222.

(1999). *Oil and the macroeconomy revisited.* Mimeo, Federal Reserve Board, Washington, D. C.

Im, K. S.; Pesaran, M. H.; Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics* 115(1): 53–74.

Ito, K. (2008). Oil price and macroeconomy in Russia. *Economics Bulletin* 17(17): 1–9.

Jiang, Q.; Cheng, S.; Cao, Y.; Wang, Z. (2021). The asymmetric and multi-scale volatility correlation between global oil price and economic policy uncertainty of China. *Environmental Science and Pollution Research* 1–12. https://doi.org/10.1007/s11356-021-16446-1.

Jiménez-Rodríguez, R.; Sánchez, M. (2005). Oil price shocks and real GDP growth: Empirical evidence for some OECD countries. *Applied Economics* 37(2): 201–228. DOI: 10.1080/0003684042000281561.

Kao, C. (1999). Spurious regression and residual-based tests for cointegration in panel data. *Journal of Econometrics* 90: 1–44.

Kumar, S. (2009). The macroeconomic effects of oil price shocks: Empirical evidence for India. *Economics Bulletin* 29(1): 15–37.

Lee, K.; Ni, S.; Ratti, R. A. (1995). Oil shocks and the macroeconomy: The role of price variability. *The Energy Journal* 16(4): 39–56.

Levin, A.; Lin, C. F.; Chu, C. S. J. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of econometrics* 108(1): 1–24.

McDonald, S.; van Schoor, M. (2005). A computable general equilibrium (CGE) analysis of the impact of an oil price increase in South Africa. *PROVIDE Project Working Paper* (No. 1854-2016-152583).

Mork, K. A. (1989). Oil and the macroeconomy when prices go up and down: An extension of Hamilton's results. *Journal of Political Economy* 97(3): 740–744.

Mory, J. F. (1993). Oil prices and economic activity: Is the relationship symmetric? *The Energy Journal* 14(4): 151–161.

Nusair, S. A. (2016). The effects of oil price shocks on the economies of the Gulf Co-Operation Council countries: Nonlinear analysis. *Energy Policy* 91: 256–267. DOI:10.1016/j.enpol.2016.01.013.

Pedroni, P. (2004). Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econometric Theory* 20(3): 597–625.

Pesaran, M. H.; Shin, Y; Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels*. Journal of the American Statistical Association* 94(446): 621–634.

Raheem, I. D. (2017). Asymmetry and break effects of oil price-macroeconomic fundamentals dynamics: The trade effect channel. *The Journal of Economic Asymmetries* 16: 12–25.

Rasmussen T.; Roitman A. (2011). Oil shocks in a global perspective: Are they really that bad? *International Monetary Fund Working Paper*. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1910497.

Salisu, A. A.; Isah, K. O. (2017). Revisiting the oil price and stock market nexus: A nonlinear panel ARDL approach. *Economic Modelling* 66: 258–271.

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

Shin, Y.; Yu, B.; Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In: Sickles, Robin C.; Horrace, William C. (eds.), *Festschrift in honor of Peter Schmidt*. New York: Springer. 281–314.

Su, C. W.; Huang, S. W.; Qin, M.; Umar, M. (2021). Does crude oil price stimulate economic policy uncertainty in BRICS? *Pacific-Basin Finance Journal* 66: 101519.

Suleiman, M. (2013). *Oil demand, oil prices, economic growth and the resource curse: An empirical analysis*. University of Surrey (United Kingdom).

World Bank. (2019). *World development indicators 2019*. The World Bank.

Ziramba, E. (2010). Price and income elasticities of crude oil import demand in South Africa: A cointegration analysis. *Energy Policy* 38(12): 7844–7849.