



## Oil Price Change and Economic Growth: Evidence from Net Sub-Saharan Africa Oil Exporting Countries

Umar Tijjani Babuga<sup>1,2\*</sup>, Niaz Ahmad Mohd Naseem<sup>3</sup>

<sup>1</sup>Department of Economics, Universiti Putra Malaysia, Serdang 43400, Selangor Darul Ehsan, Malaysia, <sup>2</sup>Department of Economics, Yusuf Maitama Sule University, Kano. PMB 3220, Kano, Nigeria, <sup>3</sup>Department of Economics, Universiti Putra Malaysia, Serdang 43400, Selangor Darul Ehsan, Malaysia. \*E-mail: [mrbabuga@gmail.com](mailto:mrbabuga@gmail.com)

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### ABSTRACT

This paper aimed at examining the long run relationship between the oil price change and economic growth for Sub-Saharan Africa (SSA) net oil exporters (Angola, Cameroon, Congo (Democratic Republic), Congo (The Republic), Equatorial Guinea, Gabon and Nigeria) with the sole purpose of pinpointing the threshold level where an increase beyond that is no longer or even contributing negatively to the economic growth of these countries. Based on the dynamic heterogeneous panel PMG estimation, the empirical results show that a threshold level exists between oil price increase and economic growth for these countries, where an increase in oil price ( $op^2$ ) depicts a negative sign which is non-linear and at the same time signifying an inverted u shape relationship with the *real GDP* ( $rgdpc$ ) as an indicator of economic growth. As the finding suggested, the rising oil price above certain threshold triggers fall in *real GDP*. However, the economies of these countries depend largely on oil revenue, therefore, economic diversification, saving and investing the excess of crude oil revenue at the time of higher oil prices became necessary to them in order to prevent their economies against the vagaries of volatility and uncertainty of the oil price.

**Keywords:** Oil Price, Oil Price-Squared, Economic Growth, Inverted-u Shape

**JEL Classifications:** E3, Q41, Q43

### 1. INTRODUCTION

It is widely accepted that large number of businesses and economic activities require energy as important input in their production process, and one of the major sources of that energy is crude oil. The importance of crude oil in the production process is what prompted many countries around the world to be paying much attention on the issues related to oil price and its shocks over the past few decades due to its impressive impact on the real economy (Narayan et al., 2014). In contrast, the case is different to oil exporting countries, one important thing to them is the transfer of income channel. Consequently, an increase in oil price is leading to transfer of wealth from oil importing to oil exporting countries which may cause the rise of national income via larger export earnings which is also expected to boost consumer demand

and purchasing power of the citizenry (Nusair, 2016). Similarly, Rotimi and Ngalawa (2017) find that an appreciation in the price of oil contributes to economic growth by providing the needed financial resources for the developmental activities in oil exporting countries.

Notwithstanding, the issue of oil price increase is not always being good to oil exporting countries especially due to the effect of Dutch disease. Dutch disease may ensue if the higher oil revenue to these countries frequently render their real exchange rates overly appreciated. And if the real exchange rate of an economy is overvalued, exports of other sectors such as manufacturing and agriculture may likely be neglected, which has implications for growth (Beverelli et al., 2011). Apart from the effect of Dutch

disease, these countries are also facing problem of mismanaging the extra money they generated from the sales of crude oil at higher prices in the global oil market. They spend substantial amount of the money generated through giving of subsidy to the citizens on the importation of refined petroleum products. They are also embarking on big projects which might take a longer completion period and requiring huge amount of money out of the extra revenue from the sales of crude oil at higher prices (Rotimi and Ngalawa, 2017).

The debate on the nexus between oil price and growth/development has been widely discussed among scholars. It is argued that there is positive relationship between oil price changes and economic development so that increase in global oil price will affect oil exporting countries positively and falling oil price will affect these countries negatively. This narrative show that revenue from oil price serves as an important income source for growth and development. For example, most of the oil exporting countries, including Sub-Saharan Africa (SSA) region are heavily dependent on oil revenue for their income and spending. Hence, shocks in oil price is certainly going to affect the level of economic activities in these economies. Rotimi and Ngalawa (2017), for instance, find a significant and positive relation between positive oil price shock and economic performance of oil exporting African countries. This is because obviously, appreciation in the price of oil contributes to economic growth by providing the needed financial resources for the developmental activities in oil exporting countries. In support of this notion are Ju et al. (2014), Tuzova and Qayum (2016), Wei and Guo (2016), Ratti and Vespignani (2016), Hou et al. (2016) and Sadeghi (2017), Mensah et al. (2019); Awartani et al. (2020); Charfeddine and Barkat (2020), Abdelsalam (2020) among others.

Contrarily, there are empirical studies which find that higher oil prices with huge revenue does not always translate to a sustained economic growth of those oil exporters. In fact that might even go to the extent of worsening the economic conditions of immense importance to growth and development through appreciations in the value of local currency, rent seeking and poor policy making (Moshiri and Banihashem, 2012). This is further supported by (Nusair, 2016), the author indicated that shock from oil price change can affect economy in many dimensions, one of them is for the economy to be affected negatively, that is when the rising oil price worsen economic condition, contributing to economic growth through currency appreciation, rent seeking and poor policy making (Moshiri and Banihashem, 2012). In a similar manner, Lucky and Andrew (2016) indicate that oil revenue from the higher oil price is not contributing to the growth of Nigerian economy due to the effect of Dutch disease.

In the same vein, by using a quarterly data spanning 1990Q1 to 2016Q4 for Pakistan, Yasmeen et al. (2021) applied a Structural equation model to investigate the nexus between natural resources and economic growth. The findings indicate that abundance of natural resource is negatively affecting the economic growth. Likewise, Eyden et al. (2019), Katircioglu et al. (2015) find that the price of oil is negatively impacting the economic growth of OECD countries in general, including the oil exporters among them. In the same vein, Alkhateeb and Sultan (2019), Akinsola and

Odhiambo (2020), Kriskkumar and Naseem (2019), Akhmad et al. (2019) all find that, it is a negative relationship that exists between oil price changes and economic growth for different countries. Similarly, Moshiri (2015) indicated that different responses to oil price shock can be explained according to the individual country's differences in terms of institutional quality. Institutional quality as humanly devised constraint that shapes human interaction helps the society evolves through time, and hence the direction of economic performance (North, 1990). Mostly, in oil exporting developing countries, the higher oil price accompanied with huge revenue do not translate into sustained economic growth. Nevertheless, there is an argument that the impact of oil price fluctuation to economic growth is neither positive nor negative rather the effect is even unclear or neutral. Trang et al. (2017) argued that the effect of to the growth of oil exporting country still remains unclear.

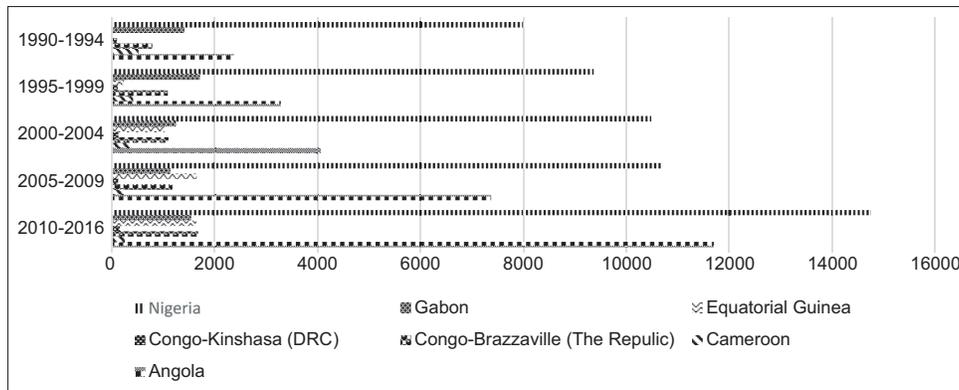
The production of oil started in the region of Sub-Saharan Africa (SSA) since 1960s, and it has been growing gradually since that time, except for a period of small disruption in the early 1980s due to the then collapse of oil prices. Currently, more than 500 oil companies participate in the activities of hydrocarbon exploration in the whole African region (OPEC (1), 2017). The continent has large deposit of oil laid down in its various countries, according to figures, Africa's proven oil reserves have increased by almost 120 percent in the last 30 years or so, from 57 billion barrels in the 1980's to around 124 billion barrels in the millennium and the contribution of the continent to the world daily oil production is about 9.4percent (OPEC (2), 2017). Moreover, it is estimated that there is at least another 100 billion barrels which are on the offshore of African continent, only waiting to be explored (E.I.A., 2013).

Sub-Saharan Africa consists of 54 countries out of which only 7 are deemed to be net oil exporting, namely Angola, Cameroon, Congo (The Republic), Congo (Democratic Republic), Equatorial Guinea, Gabon and Nigeria. The selection of the countries was carried out by comparing the amount of exports and imports of crude oil for all the 54 SSA countries for 27 years (1990-2016), finally seven countries emerged to be net oil exporting as their exports exceeds import levels throughout. These countries maintained a consistent positive net oil exporting for quite a long period of time. This is indicated in the following Figure 1, which shows the consistent export of oil for 27 years (1990-2016) among these oil rich countries.

These countries share the same race but different tribes, they speak different languages (both native and official), some are Anglophones while some are Francophones. Religious wise, different faiths are found across the nations. One special thing that these countries have in common is that they produce and export oil and their economies are heavily dependent on it for revenue and export earnings.

Figure 2 indicate the co-movement between SSA net oil exporting countries' nominal GDPC and WTI oil price. The figure indicates that the two variables are in tandem, with an excellent correlation coefficient of around 98 percent. This portrays that movements in oil price have a very significant impact on their economies. Being that, these countries are heavily dependent on oil price

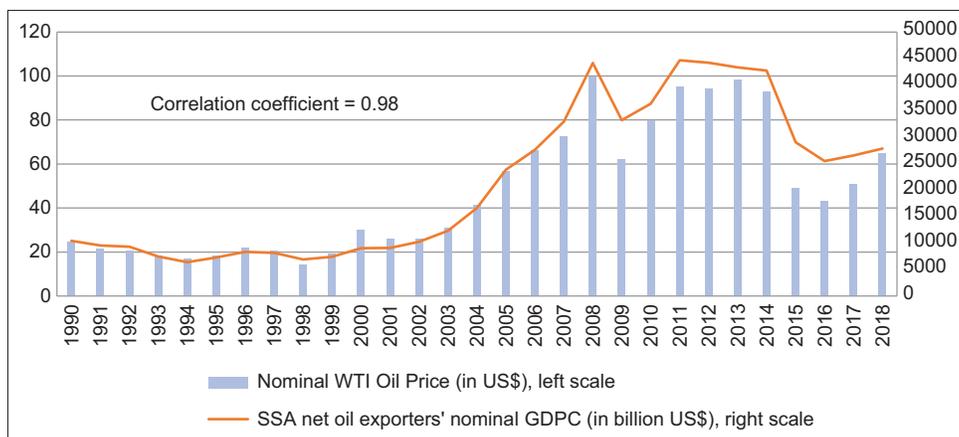
**Figure 1:** SSA net oil exports (Total oil exports minus imports)



Source: Estimated from the data obtained from EIA

Sample period: 1990-2016 for the net oil exporting countries in the SSA sub region, Angola, Cameroon, Congo (Democratic Republic), Congo (The Republic), Equatorial Guinea, Gabon and Nigeria

**Figure 2:** SSA net oil exporters' nominal GDPC and nominal WTI oil price



Source: Estimated from the data obtained from WDI and EIA

Sample period: 1990-2018 for the net oil exporting countries in the SSA sub region, Angola, Cameroon, Congo (Democratic Republic), Congo (The Republic), Equatorial Guinea, Gabon and Nigeria

as the main driver of economic growth and that is making them vulnerable to the fluctuation of that oil price in the global market. The explanation is, due to the increase in oil price, the revenue for the oil SSA exporting countries increased, then the economy witnessed more economic progress which then lead to the increase in aggregate level of output.

While there is near consensus as to adverse impact of negative oil price shock on these economies, the bond of contention is on the link between positive oil price shock and economic development. Evidence does not support the argument that substantial upward spikes in oil price must be correlated to positive economic growth with improvement in the economic condition and standard of living of the citizenry of these countries (Moshiri and Banihashem, 2012), (Nusair, 2016). This is because positive oil price shock has its attendant economic implications especially for the economies of these oil exporting countries, which mostly export only crude oil and imports virtually all they need. This will translate to higher import price due to rise in oil price, reduces living standards, leads to exchange rate appreciation, provide avenue for corruption and waste in these countries. These contributes to under development in these countries. Hence, we argue that positive oil price shock

may have positive impact on the economy but only to a certain threshold. In other words, the rise in oil price should be up to a certain point and then stabilizes. Therefore, there is need to investigate the threshold impact of oil price shock on economic development for these oil dependent countries.

Against this background, the objective of this study is to investigate the effect of oil price changes on the economic growth of SSA net oil exporting countries using dynamic heterogeneous panel (PMG) method, to what extent the oil price changes may have benefit or detriment the output. The prime purpose is identifying the threshold or turning point where the oil price increase is no longer contributing or is even negatively contributing to the economic growth of SSA oil exporting countries.

The study is imperative because it would give light on the oil price macroeconomic relationship for those small countries that relied on oil for the majority of their foreign exchange earnings in the region of SSA. It would be of vital importance to explore if the increase in oil price for those oil exporting countries is always yielding a positive impact to their economic growth or it is only beneficial to the GDP growth to a certain threshold then it would start diminishing.

Although Nusair (2016); Sadeghi (2017); Sek (2017) and Tuzova and Qayum (2016) on one hand, and on the other hand Farzanegan and Markwardt (2009); Olomola (2006); Olomola and Adejumo (2006), Awartani et al. (2020); Charfeddine and Barkat (2020), Abdelsalam (2020) have all tried to investigate this issue of oil price-macroeconomic relationship, this study is an improvement on their study for trying to pinpoint the threshold level where the increase in the price of oil is not contributing to the economic growth of oil exporting countries especially in SSA oil exporting nations where there is paucity of studies on oil price-macroeconomy relationship with regards to them and other developing countries that export oil, while there is abundance of such studies on advanced oil importing countries. To the best of authors' knowledge, this study contributes to the literature by being the first that used an *oil price squared* ( $OP^2$ ) in oil price-growth model to determine the threshold point on SSA net oil exporting countries by applying a dynamic heterogeneous panel (PMG) method.

The rest of the paper is organized as follows: section 2 explains the empirical model, methodology and data; section 3 reports the estimated results of panel unit root test, panel cointegration estimations and the interpretations of the findings while the last section concludes the discussion.

## 2. EMPIRICAL MODEL, METHODOLOGY AND DATA

The empirical specification is aimed at investigating the relationship between oil price change and economic growth for selected SSA oil exporting countries. Thus, the study follow the work of Kriskkumar and Naseem (2019) and Alkhateeb and Sultan (2019). For the purpose of this study, the model is modified for this particular research. Two models are formed (equation 1 and 2), the first model (linear) with oil price ( $op$ ) and the second (non-linear) with oil price squared ( $op^2$ ) to investigate the difference between the period of oil price change and other times:

$$lrgdpc_{it} = \alpha_{it} + \beta_1 lop_{it} + \beta_2 llifex_{it} + \beta_3 lpopt_{it} + \beta_4 lcap_{it} + \eta_i + \varepsilon_{it} \quad (1)$$

where  $lrgdpc$  is the natural log of *real GDP per capita* (constant 2010 US\$),  $lop$  is the natural log of *real oil price* (measured by WTI oil price),  $llifex$  is the natural log of *life expectancy*,  $lpopt$  is the natural log of *total population* as a measure of labour force while  $lcap$  depicts the natural log of *capital stock* or investment measured by gross capital formation (constant 2010 US\$),  $\eta$  is the unobserved individual country specific effect,  $\varepsilon$  is the independent and identically distributed error term,  $i$  is the country index while  $t$  is the time index.

The oil price, West Texas Intermediate (WTI) is used in this study, as many studies in relation to oil price applied WTI, the reason being that it is a benchmark for crude oil pricing in the international market (Zhang et al., 2008). And among the oil indices, WTI is also the most commonly used oil price index all over the world (Yang et al., 2018). The variable oil price ( $\beta_1 > 0$ ) is expected to have a positive sign as oil price increase is one important way through which the oil exporting countries are getting too much

revenue capable of increasing investments to create more jobs and employment opportunities thereby boosting the output level. In order to control the effect of nominal exchange rate variations on oil price, the WTI is transformed to real oil price by converting it to each countries' nominal exchange rate and then scale it to the respective consumer price index (CPI) of each country under the study as used by (Babuga and Naseem, 2021).

Following the work of Azman-Saini et al. (2010), the life expectancy as one of the determinants of economic growth is used as a measure human capital. For instance, Pelinescu (2015); Hanushek and Kim (1995) described that a quality labor force is among the fundamentals towards achieving a real growth in an economy. Here, it is expected to have a positive sign ( $\beta_2 > 0$ ) as more vibrant and productive labour force is produced as a result of good health care and sound education system the economic growth is expected to improve hence the output level. The total population which is used as measure of labour growth.

The population growth is relevant, is found to be affecting economic growth significantly, for instance, by Bucci et al. (2018). It is expected to have a negative sign ( $\beta_3 < 0$ ), as population grows the ratio of capital per worker is becoming less thereby aggravating the labour force and cause reduction in the level of output.

Gross capital formation is used as a measure of capital stock and investment. Capital is an important factor significantly affecting economic growth Apergis and Payne (2010), Alkhateeb and Sultan (2019) and Alfredsson and Malmaeus (2019). It is expected to have a positive sign ( $\beta_4 > 0$ ), as stock of capital will boost investments thereby creating more jobs, employments and increase in the level of output.

The oil price-economic growth relationship for these countries might also be non-linear. It would be interesting to learn if the increase in oil price for those oil exporting countries is always yielding a positive impact to their economic growth or it is only beneficial to the GDP growth to a certain threshold then it would start declining. A hypothesis of non-linear effect of oil price change on economic growth is a priori and uncertain, yet it can be empirically determined by adding a squared term of oil price to the equation (1) and re-formulated as:

$$lrgdpc_{it} = \alpha_{it} + \beta_1 lop_{it} + \beta_2 lop_{it}^2 + \beta_3 llifex_{it} + \beta_4 lpopt_{it} + \beta_5 lcap_{it} + \eta_i + \varepsilon_{it} \quad (2)$$

as suggested by Richmond and Kaufmann (2006), Constantini and Monni (2008), if  $\beta_1 > 0$  and  $\beta_2 < 0$ , then there is an inverted U-shaped relationship between the oil price increase ( $lop^2$ ) and economic growth ( $lrgdpc$ ). Under this condition, the relationship between increase in oil price and economic growth has a turning

point as exponential of  $\left| \frac{\beta_1}{2\beta_2} \right|$ . As oil price increases beyond this point, the economic growth starts declining.

### 2.1. Econometric Methodology

The pooled mean group estimator (PMG) as proposed by Pesaran et al. (1999) is the econometric method employed for this study. The pooled mean group (PMG) estimator is an intermediate between

the dynamic fixed effect (DFE) and mean group (MG) because it allows both pooling and averaging. The PMG allows short-run coefficients, speed of adjustment and error variances to vary across panels and at the same time restrict the long-run coefficients to be similar across the groups. The PMG also generates consistent estimates of the mean of the short run coefficients by taking the simple average of individual unit coefficients. The MG method of estimation assumed that both slopes and intercepts are allowed to differ across panels/countries that is why the long-run coefficients are not similar across panels while the DFE assumes the slopes are fixed while the intercepts vary across panels. The Hausman (1978) test is conducted after the estimation of PMG and MG to get the appropriate method between the two. The null cannot be rejected if the long run homogeneity exists, and therefore PMG is more efficient.

The dynamic heterogeneous panel regression can be incorporated into the error-correction model using the ARDL ( $p, q$ ) method, where  $p$  is the lag of the dependent variable, and  $q$  is the lag of the independent variables, the Akaike information criterion (AIC) is used for the selection of the lag order:

$$lrgdpc_{it} = \gamma_l lrgdpc_{i,t-1} + \delta_1 lop_{it} + \delta_2 llifex_{it} + \delta_3 lpopt_{it} + \delta_4 lcap_{it} + \sum_{j=1}^{p-1} Y_{ij} \Delta lrgdpc_{i,t-j} + \sum_{j=1}^{q-1} \beta_{ij} \Delta lop_{i,t-j} + \beta_{ij} \Delta llifex_{i,t-j} + \beta_{ij} \Delta lpopt_{i,t-j} + \beta_{ij} \Delta lcap_{i,t-1} + \eta_i \varepsilon_{it} \quad (3)$$

$$lrgdpc_{it} = \gamma_l lrgdpc_{i,t-1} + \delta_1 lop_{it} + \delta_2 (lop_{it})^2 + \delta_3 llifex_{it} + \delta_4 lpopt_{it} + \delta_5 lcap_{it} + \sum_{j=1}^{p-1} Y_{ij} \Delta lrgdpc_{i,t-j} + \sum_{j=0}^{q-1} \beta_{ij} \Delta lop_{i,t-j} + \beta_{ij} \Delta (lop_{it})^2_{i,t-j} + \beta_{ij} \Delta llifex_{i,t-j} + \beta_{ij} \Delta lpopt_{i,t-j} + \beta_{ij} \Delta lcap_{i,t-1} + \eta_i \varepsilon_{it} \quad (4)$$

where  $\delta$  is the long-run coefficient of the independent variables, and  $\gamma$  is the parameter of speed adjustment to the long-run equilibrium.  $\eta$  is the fixed effect and  $\varepsilon$  is the error term.  $i$  and  $t$  represents country and time index respectively. It is assumed that the error term  $\varepsilon$  in the PMG framework is distributed independently across  $i$  and  $t$  with zero mean and variance. The error term is also distributed independently of the regressors. Moreover, to capture the long-run relationship between dependent and independent variables, it is assumed that if the parameter of the speed of adjustment is less than zero ( $\gamma < 0$ ) for all  $i$ , then panel co-integration is expressed as:

$$lrgdpc_{it} = \phi_1 lop_{it} + \phi_2 llifex_{it} + \phi_3 lpopt_{it} + \phi_4 lcap_{it} + \mu_{it} \quad (5)$$

$$lrgdpc_{it} = \phi_1 lop_{it} + \phi_2 lop_{it}^2 + \phi_3 llifex_{it} + \phi_4 lpopt_{it} + \phi_5 lcap_{it} + \mu_{it} \quad (6)$$

where  $-\phi_1 = \delta_1 / \gamma$ ,  $-\phi_2 = \delta_2 / \gamma$ ,  $-\phi_3 = \delta_3 / \gamma$ ,  $-\phi_4 = \delta_4 / \gamma$  and  $-\phi_5 = \delta_5 / \gamma$  are the long run coefficients of oil price, real effective exchange rate, capital, labor and population growth respectively.

## 2.2. Data

In this study, annual data was utilized to estimate the long run relationship between economic growth and oil price change for SSA net oil exporting countries which covers the period of 29 years (1990-2018) on Table 1. The study, therefore, use economic growth

proxied by real GDP per capita (constant 2010 US\$) as a dependent variable while the explanatory variables are oil price (WTI) US\$, life expectancy to measure of human capital, total population as a measure of labour growth and gross capital formation as a proxy of capital stock. In order to control the effect of nominal exchange rate variations on oil price, the WTI is transformed to real oil price by converting it to each countries' nominal exchange rate and then scale it to the respective consumer price index (CPI) of each country under the study. The data of real GDP per capita, gross capital formation, life expectancy and total population were obtained from the database of world development indicators (WDI). The data of oil prices was obtained from U.S. Energy Information Administration (EIA).

Summary statistics of the data on Angola, Cameroon, Congo DRC, Congo Republic, Equatorial Guinea, Gabon and Nigeria.

## 3. EMPIRICAL RESULTS

### 3.1. Panel Unit Root Test

Being that the SSA net oil exporters are highly dependent on oil revenue as major source of their income, variation in oil prices must have a significant impact to their economies. To explore the long-term relationship between oil price change and economic growth for the panel of these countries, panel unit root test was first conducted to ensure stationarity of the variables. The Levin et al. (2002) LLC and Im et al. (2003) IPS panel unit root test results were carried out and reported in Table 2. The results show a mixture of order of integration for the variables, some are stationary at level I(0) while others at first-difference I(1). The test results indicate that under LLC (intercept) at level, variables of llifex (life expectancy) and lpopt (total population) are both significant at one percent level of significance, the variables of oil price (lop) and oil price squared (lop<sup>2</sup>) are significant at five percent and ten percent respectively, while real gdp (lrgdpc) and capital formation (lcap) are insignificant. Under LLC (intercept and trend) at level, llifex and lpopt are both significant at one percent, lrgdpc and lcap are all significant at five percent while lop and lop<sup>2</sup> are not significant. Looking at LLC (intercept) at first difference, all variables are found to be significant at one percent level of significance. LLC (intercept and trend) at first difference, all variables are found to be significant also at one percent level of significance. Under IPS (intercept) at level, only variable llifex is found to be significant at one percent while the rest of the variables are insignificant. IPS (intercept and trend) at level, llifex and lpopt are significant at one percent, lcap and lrgdpc are found to be significant five percent and ten percent respectively, while lop and lop<sup>2</sup> are found to be insignificant. IPS (intercept) at first difference, all variables are found to be significant at one percent level of significance. Under IPS (intercept and trend) at first difference, all variables are found to be significant at one percent level of significance. That make the data satisfied in fulfilling the requirement to go ahead with ARDL estimation that allowed the combination of both I(0) and I(1) variables, hence the panel cointegration estimation such as MG, PMG and DFE.

### 3.2. PMG Results

Firstly, the equations were estimated applying PMG, MG and DFE methods. Hausman test was carried out between the PMG and MG

estimations in order to find out the efficient estimate among the two. Failure to reject the null hypothesis signifies that PMG is the preferred technique while rejection of the null is indicating the MG is more efficient. In this study, for both linear and nonlinear models, the outcome of the Hausman test clearly indicate PMG is the efficient technique preferred over the MG for modelling oil price-economic growth relationship as the null hypothesis could not be rejected. Therefore, only the results from the efficient and preferred estimate (PMG) as indicated by the Hausman test results are going to be reported in this study.

The long run relationship is estimated using a dynamic heterogeneous panel Pooled Mean Group (PMG) technique. The PMG method, being an ARDL based method have an advantage of allowing the mixture of I(0) and I(1) variables and it restricts the long run parameters to be homogenous after tolerating them to differ in the short-run, so the long run homogeneity is the aim to be achieved. The results from the PMG, MG and DFE estimations are presented in Table 3 for linear model and Table 4 for the non-linear model.

For the linear model as presented on Table 3, which examines a linear relationship between economic growth and oil price as variable of interest. The variable oil price is found to be positive as expected and significant at 1 percent level of significance with a coefficient value of 0.119 signifying that, increase in oil price by 1 percent leads to an increase in real GDP by 0.119 percent. For the remaining explanatory variables, life expectancy is positive and significant at 1 percent level of significance with coefficient value of 2.610 denoting a 1 percent increase in life expectancy (as a measure of human capital) leads to an increase in real GDP by 2.610 percent. The total population as measure of labor force growth is also significant and negatively signed as expected with coefficient value of -0.504. This indicates, as total population increases by 1 percent, the real GDP will shrink by 0.504 percent. The gross capital formation which is used as a measure of capital stock is statistically insignificant even though positively signed as expected. The findings indicate that oil price change affect economic growth of the SSA oil exporting countries, and this is consistent with the findings of (Hou et al., 2016; Rotimi and

**Table 1: Summary of annual data set (1990-2018) n=7**

	Source	Unit of measurement	Mean	SD	Max	Min
<i>rgdpc</i> (real gdp per capita)	WDI	Constant 2010 US\$	4160.421	4660.195	20512.9	276.056
<i>oil price</i> ( <i>wti</i> )	EIA	US\$ per barrel	47.4796	28.6778	99.75	14.4
<i>lifex</i> (life expectancy)	WDI	Number of years	54.09793	5.164625	66.187	45.201
<i>popt</i> (total population)	WDI	Number of people	3.41e+07	4.85e+07	2.00e+08	419188
<i>cap</i> (gross capital formation)	WDI	constant 2010 US\$	9.85e+09	1.51e+10	7.50e+10	5.20e+07

**Table 2: Results of dynamic heterogeneous panel MG, PMG and DFE estimations. Dependent variable: Real GDP per capita, linear model**

Dependent variable: real GDP per capita	Lag order (1,2,2,1,1)		
	Mean Group	Pooled Mean Group	Dynamic Fixed Effect
<i>Convergence coefficient</i>	-0.6238*** (0.1010)	-0.3683*** (0.0820)	-0.0732*** (0.0183)
<i>Longrun coefficient</i>			
<i>lop</i>	0.1899* (0.1128)	0.1196*** (0.0351)	0.7726** (0.3277)
<i>llifex</i>	-3.5943 (4.7028)	2.6106*** (0.5650)	21.0784*** (7.5064)
<i>lpopt</i>	1.1440 (1.2070)	-0.5040*** (0.1420)	-5.1235** (2.0522)
<i>lcap</i>	-0.0000 (0.0637)	-0.0104 (0.0139)	-0.2674* (0.1420)
<i>Shortrun coefficient</i>			
<i>Δlop</i>	0.0303* (0.0160)	-0.0004 (0.0158)	-0.0081 (0.0209)
<i>Δllifex</i>	-12.9041 (30.6370)	-19.3070 (24.6972)	22.9671*** (8.6208)
<i>Δlpopt</i>	32.9986 (25.0086)	6.7939 (10.5470)	4.7313* (2.6898)
<i>Δlcap</i>	0.0365* (0.0205)	0.0286* (0.0169)	0.0132 (0.0141)
<i>No of countries</i>	7	7	7
<i>No of observations</i>	189	189	189
<i>Log likelihood</i>		400.2058	
<i>Hausman test for long run homogeneity</i>		3.47 (0.4823)	

Figures in parentheses are asymptotic standard errors except for Hausman test which is P value. AIC criterion is used to choose the lag order. \*\*\*, \*\*, \* Significant at 1%, 5% and 10% respectively

**Table 3: Levin-Lin-Chu (LLC) and Im-Pesaran-Shin unitroot test**

	Level				First Difference			
	Intercept		Intercept and trend		Intercept		Intercept and trend	
	LLC	IPS	LLC	IPS	LLC	IPS	LLC	IPS
<i>lrgdpc</i>	-1.0447	-0.0732	-1.9443**	-1.3408*	-3.7039***	-3.5634***	-3.3451***	-2.4228***
<i>lop</i>	-1.6916**	-0.8368	-0.7401	-0.0051	-7.3983***	-8.2574***	-5.6427***	-7.0389***
<i>lop<sup>2</sup></i>	-1.6192*	-0.8119	-0.6770	0.0587	-7.2229***	-8.1055***	-5.4469***	-6.8647***
<i>llifex</i>	-10.6319***	-9.5468***	-33.9306***	-40.6729***	-20.5507***	-18.7571***	-17.2949***	-15.7909***
<i>lpopt</i>	-3.8630***	-0.1932	-16.0373***	-17.2898***	-6.7075***	-7.3533***	-8.1959***	-6.8401***
<i>lcap</i>	0.9330	1.9861	-2.1373**	-2.0454**	-6.1162***	-6.1589***	-4.7300***	-4.8410***

\*\*\*, \*\*, \* Significant at 1%, 5% and 10% respectively

**Table 4: Results of dynamic heterogeneous panel MG, PMG and DFE estimations. Dependent variable: *real gdp*, non-linear model**

Dependent variable: real GDP per capita	Lag order (1,2,2,2,1)		
	Mean Group	Pooled Mean Group	Dynamic Fixed Effect
<i>Convergence coefficient</i>	-0.5738*** (0.1253)	-0.2827*** (0.0632)	-0.0799*** (0.0193)
<i>Longrun coefficient</i>			
<i>lop</i>	3.9097* (2.0563)	1.4504*** (0.3697)	1.8360* (1.0424)
<i>lop<sup>2</sup></i>	-0.3918** (0.1900)	-0.1184*** (0.0325)	-0.1137 (0.1019)
<i>llifex</i>	13.8663 (14.9684)	4.4768*** (0.7106)	19.9181*** (7.1999)
<i>lpopt</i>	-3.2570 (3.9744)	-0.7496*** (0.2073)	-4.6605** (1.9921)
<i>lcap</i>	-0.0568 (0.0893)	-0.0275* (0.0167)	-0.2679** (0.1314)
<i>Shortrun coefficient</i>			
<i>Δlop</i>	0.8623 (1.0190)	0.1983 (0.3384)	0.0763 (0.0984)
<i>Δlop<sup>2</sup></i>	-0.0736 (0.0897)	-0.0124 (0.0332)	-0.0089 (0.0103)
<i>Δllifex</i>	-24.2478 (27.9490)	-12.1613 (27.1598)	25.0414*** (9.6261)
<i>Δlpopt</i>	0.1981 (27.1924)	28.2121 (27.6475)	-5.3846 (7.1809)
<i>Δlcap</i>	0.0280 (0.0174)	0.0303* (0.0173)	0.0157 (0.0143)
<i>Turning point</i>		6.125 (457.144)	
<i>No of countries</i>	7	7	7
<i>No of observations</i>	189	189	189
<i>Log likelihood</i>		425.2188	
<i>Hausman test for long run homogeneity</i>		5.23 (0.3887)	

Figures in parentheses are asymptotic standard errors except for Hausman test which is P value. AIC criterion is used to choose the lag order. \*\*\*, \*\*, \* Significant at 1%, 5% and 10% respectively

Ngalawa, 2017; Tuzova and Qayum, 2016b), Awartani et al. (2020); Charfeddine and Barkat (2020), Abdelsalam (2020) The error correction (ECT) speed of adjustment parameter for PMG is -0.368, it is significant at 1 percent level of significance and correctly signed negative which is indicating that any deviation from the long run equilibrium in the short run can be corrected at 36.8 percent speed of convergence to the long run equilibrium. And it also signifies the duration that it takes to converge to the long run equilibrium is 2.27 years. The error correction term of MG and DFE are also significant both at 1 percent level of significance with a corresponding coefficient of -0.623 and -0.073 percent respectively. The speed of adjustment even though reduced from MG to PMG, but PMG is the appropriate from the Hausman result between the methods. The Hausman test result of 3.47 with a corresponding P = 0.482 indicates the existence of long run homogeneity, therefore PMG is the more efficient and preferred method over MG.

For the non-linear model (equation 2) the results are presented on Table 4, which investigated a quadratic non-linear relationship between economic growth and oil price and oil price squared (OP<sup>2</sup>) as variables of interest. The variable oil price is found to be positive, and oil price<sup>2</sup> negative as expected, both are significant at 1 percent level of significance with a coefficients value of 1.450 and -0.118 respectively, indicating that increase in oil price by 1 percent leads to an increase in real GDP by 1.45 percent, and conversely, continuous increase in oil price (OP<sup>2</sup>) by 1 percent at a point beyond the threshold level of 6.125 (457.144) leads to decrease in real GDP by 0.118 percent. For the remaining explanatory variables, life expectancy is significant at 1 percent and positively signed with coefficient value of 4.476 showing a 1 percent increase in life expectancy which is used to measure human capital leads to an increase in real GDP by 4.476 percent. The labor force growth which is measured with total population is significant at 1 percent and negatively signed as expected with a coefficient value of -0.749, indicating a 1 percent increase in total

population is leading to a decrease capital/labor ratio as capital will be spread sparsely across the increased population thereby causing a reduction in real gdp by 0.749 percent. Gross capital formation as a measure of capital stock is found to be statistically significant at 10 percent but negatively signed, indicating a 1 percent increase in capital stock is decreasing the real gdp by 0.027 as these economies are largely depending on oil revenue neglecting production and manufacturing sector. The findings indicate that oil price change has a non-linear relationship with economic growth of the SSA net oil exporting countries. The error correction (ECT) speed of adjustment parameter for PMG is -0.282, it is found to be significant at 1 percent and correctly signed, the negative sign is depicting that any deviation from the long run equilibrium in the short run can be converged at 28.2 percent speed of adjustment to the long run equilibrium. The error correction term (ECT) is also indicating the duration of time that it takes to converge to the long run equilibrium is 3.54 years. The results show the ECT of MG and DFE are both significant at 1 percent level of significance with a corresponding value of -0.573 and -0.079 respectively. The speed of adjustment even though is higher on the MG result than PMG, yet PMG is the appropriate technique as indicated by the Hausman test result. The Hausman test result is 5.23 indicating a non-rejection of the null with a corresponding p value of 0.388 signifying the presence of long run homogeneity and absence of long run heterogeneity, therefore PMG is the more appropriate technique over MG.

The result is consistent with the findings of Moshiri and Banihashem (2012), Lucky and Andrew (2016), Yasmeeen et al. (2021) that higher oil prices with huge revenue does not always translate to a sustained economic growth of those oil exporters, in fact that might even go to the extent of worsening the economic conditions of immense importance to growth and development. And the findings are also similar to the results of (Eyden et al., 2019). For the remaining control variables, the results indicate that life expectancy, total population play a significant role in

determining economic growth for the SSA oil exporting countries except gross capital formation which deemed insignificant.

The result is in support of the Kuznets (1955) and later developed in (1963) inverted-U hypothesis. According to this hypothesis, as per capital national income of a country rises at an initial stage, income inequality also rises but up to a certain level then falls as per capita national income raises further. Similarly, it is found in this study that as oil price rises, it contributes to the economic growth of SSA oil exporting countries but up to a certain level then falls as oil prices raise further above that level.

### 3.3. Robustness Checks

For robustness check, this study makes use of another alternative of oil price (Brent) by applying a similar method (PMG) on both

the linear and non-linear models to check the sensitivity of the results to variable measurement. For the Brent oil price, the use of PMG method on linear model (Table 5) also indicates the variables incorporated are the important determinants of economic growth.

Table 6 presents the non-linear model also using Brent oil price, the empirical results verify the existence of an inverted-U shape relationship between the oil price increase and economic growth which allows for turning point estimation just like the result given by using WTI, the turning point results for using PMG on Brent crude oil was found to be 4.0357 (56.5825). The result of the *Hausman test* by using Brent also indicates we cannot reject the null and the long-run homogeneity exists between the panels, therefore, PMG is more efficient and the result is robust to different proxy of oil price (Brent).

**Table 5: Results of dynamic heterogeneous panel MG, PMG and DFE estimations. Dependent variable: real gdp, linear model**

Dependent variable: real GDP per capita	Lag order (1,3,3,3,3)		
	Mean Group	Pooled Mean Group	Dynamic Fixed Effect
<i>Convergence coefficient</i>	-0.8019*** (0.1544)	-0.3173*** (0.1030)	-0.0573*** (0.0184)
<i>Longrun coefficient</i>			
<i>lop</i>	0.4789 (0.3685)	0.0340*** (0.0122)	0.2465** (0.1120)
<i>llifex</i>	-4.2341 (27.0424)	-1.6616*** (0.5121)	22.4996** (11.1627)
<i>lpopt</i>	3.8304 (6.4904)	0.9673*** (0.1051)	-6.2271* (3.2028)
<i>lcap</i>	0.0860 (0.0652)	0.0478 (0.0320)	-0.2507 (0.2403)
<i>Shortrun coefficient</i>			
<i>Δlop</i>	-0.0408 (0.0326)	0.0353 (0.0337)	0.0251* (0.0147)
<i>Δllifex</i>	-194.6503 (207.6207)	117.3481 (85.7682)	27.6029 (25.8531)
<i>Δlpopt</i>	0.2344 (0.4925)	0.5560 (0.6414)	0.1402 (0.3267)
<i>Δlcap</i>	-0.0424 (0.0267)	-0.0202 (0.0212)	0.0141 (0.0149)
<i>No of countries</i>	7	7	7
<i>No of observations</i>	182	182	182
<i>Log likelihood</i>		457.57	
<i>Hausman test for long run homogeneity</i>		6.19 (0.1857)	

Figures in parentheses are asymptotic standard errors except for Hausman test which is P value. AIC criterion is used to choose the lag order. \*\*\*, \*\*, \* Significant at 1%, 5% and 10% respectively

**Table 6: Results of dynamic heterogeneous panel MG, PMG and DFE estimations. Dependent variable: real gdp, non-linear model**

Dependent variable: real GDP per capita	Lag order (1,2,2,2,1,2)		
	Mean Group	Pooled Mean Group	Dynamic Fixed Effect
<i>Convergence coefficient</i>	-0.9552*** (0.1077)	-0.4178*** (0.1194)	-0.0586*** (0.0181)
<i>Longrun coefficient</i>			
<i>lop</i>	-0.1092 (0.2123)	0.1130* (0.0617)	0.5959** (0.2594)
<i>lop<sup>2</sup></i>	0.0220 (0.0142)	-0.0140** (0.0064)	0.0033 (0.0113)
<i>llifex</i>	16.6946 (15.0377)	1.7269*** (0.2682)	19.2917* (9.9846)
<i>lpopt</i>	-2.4005 (1.8933)	-0.5439*** (0.0682)	-5.4860* (2.8847)
<i>Lcap</i>	0.1614** (0.0785)	0.2057 (0.0418)	-0.4772 (0.2904)
<i>Shortrun coefficient</i>			
<i>Δlop</i>	-0.0464 (0.0392)	0.0337 (0.0232)	0.0231 (0.0143)
<i>Δlop<sup>2</sup></i>	-0.0067 (0.0153)	0.0056 (0.0099)	-0.0034*** (0.0013)
<i>Δllifex</i>	-188.7618 (135.4478)	85.9002* (48.8378)	19.6356 (26.0902)
<i>Δlpopt</i>	1.0573 (0.7542)	0.3970* (0.2229)	0.1921 (0.2326)
<i>Δlcap</i>	-0.0663 (0.0287)	-0.0170 (0.0138)	0.0162 (0.0144)
<i>Turning point</i>		4.0357 (56.5825)	
<i>No of countries</i>	7	7	7
<i>No of observations</i>	182	182	182
<i>Log likelihood</i>		427.8138	
<i>Hausman test for long run homogeneity</i>		1.89 (0.7562)	

Figures in parentheses are asymptotic standard errors except for Hausman test which is P-value. AIC criterion is used to choose the lag order. \*\*\*, \*\*, \* Significant at 1%, 5% and 10% respectively

## 4. CONCLUSION AND POLICY RECOMMENDATIONS

This study examined the relationship between oil price change and economic growth for SSA oil exporting countries. Even though oil price which is a major source of these countries' earnings and is seen as a bedrock toward achieving their economic growth, but no available study carried out to investigate the threshold level upon which that oil price stagnates in giving contribution towards that, in fact any increase in the oil price beyond that point will even result to negative growth. That level is what is called a "turning point." Based on the dynamic heterogeneous panel PMG estimation, the empirical results show that a threshold level exists between oil price increase and economic growth for these countries. Oil price and increase in oil price (squared term of oil price) depicts a positive and negative sign respectively indicating non-linearity and signifying an inverted u shape relationship with the gdp per capita (*lrgdpc*) as an indicator of economic growth. The empirical results were robust to alternative proxy of oil price (Brent) by using the same technique (PMG).

As the findings indicates from a linear model that oil price increase is positively affecting the real GDP in the study area, then a non-linear model is employed which shows that rising oil price above certain threshold reduces real GDP, so also falling oil price too decreases real GDP. These rising and falling of oil price have a serious policy implication to these countries as their economies are heavily dependent on oil as the main driver of economic activity. Diversification, therefore, is a pressing issue to SSA oil exporting countries since oil is a limited resource and its revenues are uncertain and volatile. These countries should adopt policy measures to enlarge and diversify to other economic sectors. Such policies should include adopting reforms to promote the development of other non-oil tradable sector, encouraging the development of private sector investment, improvement in the effectiveness of the public sector and so on.

Another important policy recommendation based on the findings of this study is for the SSA net oil exporters to create an oil stabilization fund. The aim of the fund will be to save the excess of the revenue obtained during the period of higher oil price and use it to settle the fiscal constraints at the time of unstable oil price. The stabilization fund will be used to settle the short run fiscal imbalance by detaching the public expenditure from the direct effect of oil price uncertainty (Sturm et al., 2009). The fund can also be used to settle the long run fiscal imbalances by investing in the long-term financial assets which even in the oil price fall or when it is depleted the country can fall back on these investments for revenue generation to bridge the gap.

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