Oil Prices and Economic Growth In Oil Producing Countries: A Panel Data Approach

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Received November 7, 2022
Revised March 7, 2023
Accepted March 15, 2023

Abstract

Oil prices have garnered increasing attention from academia, international communities, international organisations, oil companies, policymakers, and governments. This study examines the OPEC members' economic growth regarding oil price, oil production, capital, and labour stocks. The study used the Augmented Dickey-Fuller (ADF) to test for unit roots among the variables. The test result shows that although none of the variables is stationary at level, they are all stationary at first difference. Based on the Hausman test, the fixed effect was the suitable analysis method. The study, therefore, found that oil production is not significant in influencing the economic growth of OPEC member countries.
In contrast, oil prices, labour force, and capital formation significantly affect countries' economic growth. The relationship between oil prices and oil-producing countries' economic growth is negative. The study recommends that OPEC member countries develop competitive goods and services to serve as an alternative source of generating revenue. It was also recommended that oil-producing countries should take advantage of their labour force by developing them and making them available for brain export to improve foreign currency inflow in the medium term.

Keywords: Oil Prices, Economic Growth, OPEC, Panel Data
JEL Codes: Q40, F43, F53, O19

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1. Introduction

The price of oil has become a major concern for most oil-producing nations due to the volatility of oil prices over time. The oil cost has continued to fluctuate, and it has caused many disturbances among the oil-exporting countries, particularly those whose economy depends solely on oil. Different studies have examined the various causes of crude oil price fluctuations. Many have also discussed theories and metrics that attempt to assess price changes' impact on countries' economic growth and development.

Historical Movement of Oil Prices

Oil price regulation started in 1970, with oil prices averaging 2.96 USD. This birth the period for crude oil price fluctuations. In 1973, The Organisation of Petroleum Exporting Countries (OPEC) placed an embargo on selected countries as a result of the attack on Israel by Egypt and Syria, leading to a fall in total production output by 7.5% globally and consequently causing the oil price to double to about 12.5 USD (Hamilton, 2015). Iran's oil production fell by about 4.5 mbpd in 1978 due to the Iranian Revolution. Additionally, this led to a surge in price to 21 USD, leading to a continuous increase in the oil price (Amadeo, 2020).

A second major oil crisis closely followed the oil crisis of 1973/1974 in 1979/1980, when the cost of West Texas Intermediate crude oil increased to about 40 USD at the beginning of the second quarter of 1980 from below 15 USD per barrel in the third quarter of 1978. Similarly, in 1973/1974, governments responded to increasing oil prices by controlling prices and rationing gasoline, leading to long queues' recurrence at gas stations (Baumeister & Kilian, 2016). This hike resulted from the Iranian revolution (Hamilton, 2003). As soon as supply was normalised, oil prices declined until 1990. In 1990, another outbreak of the Gulf War occurred when Iran invaded Kuwait, which dropped global supply by about 8.8%, and oil prices subsequently increased (Hamilton, 2003). The crude oil price grew consistently from the turn of the 21st century up to 2008 when the price fell due to the global financial crisis.

The financial crisis of 2008 to 2009 also dealt a significant blow to the price of oil globally. The price of oil dropped from about 100 USD to almost $35. The financial market weakened, which affected global spending and negatively impacted oil prices. Shortly after the financial crisis in 2008, the oil price increased to about 110 USD in 2013. The prices of oil have dropped by about fifty percent since June 2014, likely marking the end of four years of high prices (Baffes et al., 2015). The latest advancement in oil markets and modest growth projections in evolving and emerging economies show that prices could remain soft for some years. Particularly with the past occurrences of such sharp falls accompanied by high variations in activity and inflation, the causes and results of potential policy reactions to the recent drop in oil prices have led to thorough debates (Baffes et al., 2015). After 2015, the oil price has not been stable, with prices fluctuating and falling as low as 33.16 USD. The price became stable and averaged about 53 USD until 2019 (Macrotrends, 2020).

From January 2020, travel restrictions and movement control were imposed by many nations' governments. Furthermore, businesses were closed to control the spread of the coronavirus pandemic. Oil demand started to fall. Between January and March 2020, the average oil consumption was 94.4 MBPD, indicating a shortfall of 5.6 MBPD from the previous year (U.S. EIA, 2020a). By April, forty percent of the global population had to follow Movement Control Order (MCO), therefore staying at home strictly; hence, further weakening demand (Amadeo, 2020). Between January and March 2020, OPEC and its members had a binding understanding to limit production. The agreement expired on March 31, 2020. Another meeting was held on March 6, 2020, in which Russia declined the call to limit production. OPEC responded by declaring that it would upturn production. As storage facilities filled, the prices dropped to negative. All nations were not interested in oil delivery since there was a storage problem. As of April 20, 2020, the price for a barrel of oil had dropped to -$36.98 (U.S. EIA, 2020a). On April 12, 2020, Russia and OPEC reached an agreement to reduce output to adjust prices[5].

State of the Art

Most oil price studies assessed the causes and effects of oil price fluctuations. The reasons for changes in oil prices have been attributed to the interaction between the demand and supply of crude oil (Mead & Stiger, 2015; Baumeister & Kilian, 2016). Findings by Baumeister and Kilian (2016) show that oil prices tend to be remarkably closely linked with good times for the global economy. This is supported by Hamilton (2009) and Kilian and Hicks (2013). They noted that as the global economy booms, industrial raw material demand increases, increasing crude oil demand. Demirer et al. (2020) also confirmed this by implying that crude oil is not just a commodity of international trade but also serves as an indicator of global outlook expectations in the international financial market. Oil price changes affect countries' economies depending on their role as either oil-exporting or oil-importing nations. Oil-exporting nations like Russia, UAE, Indonesia, and Kazakhstan benefit from oil price increases, while for oil-importing nations, the impact varies (Taghizadeh-Hesary et al., 2019).

The latest improvements in the crude oil market and the advent of large global external imbalances have rekindled the established policy dialogue on oil prices' role in defining external balances (Rebucci & Spatafora, 2006). There has been an increase in U.S. shale oil production, leading to continuous oil supply growth. The U.S. oil production grew by 2.2 mbpd in 2018, which is the highest annual growth ever recorded by any country (BP., 2019). The outbreak of the novel coronavirus in November 2019, which turned into a global pandemic, has caused much disruption in the global economy. The oil sector was not exempted as the pandemic affected oil prices in the international oil market. The pandemic caused a surge in demand for oil as the global economy was near a total halt (U.S. EIA, 2020a). However, the pandemic is still ongoing, with no certainty as to when it will end.

The price of oil has continued to fluctuate and has some underlying effects on the economies of both oil-producing and oil-importing countries. This has led to many studies on crude oil prices. Many studies have assessed the impact oil price fluctuation has on countries' economies (see; Abeysinghe, 2001; Bergmann, 2019; Ftiti et al., 2016; Gazdar et al., 2019; Gounder & Bartleet, 2007; Grigoli et al., 2019; Idrisov et al., 2014; Ito, 2010; Jarrett et al., 2019; Jawadi & Ftiti, 2019; Kocaarslan et al., 2020; Mallick et al., 2018; Mo et al., 2019; Mokni, 2020; Naifar et al., 2020; Nonejad, 2020; Nusair & Olson, 2019; Rano, 2009; Salisu & Isah, 2017; Thorbecke, 2019; van Eyden et al., 2019).

[5] OPEC. (2020, June 23). *The 10th (Extraordinary) OPEC and non-OPEC Ministerial Meeting concludes.* Retrieved from Organization of the Petroleum Exporting Countries: https://www.opec.org/opec_web/en/press_room/5891.htm

As a valuable global resource, the fluctuation of crude oil prices has some underlying effect on the world's countries. There has been continuous debate about the consequence of oil prices on nations' economic growth. Abeysinghe (2001) noted that the impact of oil prices on growth might not be very significant for a large nation like the United States. However, it could play a dire role in small open economies. The fall in oil prices will result in a significant real income shift to oil importers from the oil exporters. This will probably result in a net positive effect on global activity in the medium term (Baffes et al., 2015). The research shows that a supply-driven fall of 45 percent in the price of oil will result in a 0.7 to 0.8 percent rise in global GDP in the medium term and a transitory fall in global inflation of about one percentage point in the short term. The research does not show the effect of oil price changes on individual OPEC nations' economies.

The dynamics between oil price and growth component led the researchers to conduct empirical research on the subject matter. Hence, this paper is an effort to showcase up-to-date evidence by covering data from 13 countries from 2010 to 2019. This study contributes to the existing literature in the following ways: (i) This study employs the Cobb-Douglas production function to investigate the specific impact of oil prices on each of the 13 OPEC country's economic growth. The study shows that increased oil prices lead to higher domestic prices, which could increase the interest rate and affect the level of production in an economy. Therefore, this study incorporates oil prices as a factor of production in the augmented model. (ii) The study also assesses the level of dependence of OPEC member countries on oil. This is an important contribution as dependence on oil makes a country susceptible to fluctuations in the international prices of crude oil. The study applies panel data estimators ranging from fixed effects, and random coefficients (R.C.s) as used by Van Eyden et al. (2019). (iii) By making use of the growth model developed by Solow (1956), we also augmented the production function to examine the relationship between oil production and economic growth.

Our results showed the existence of a significant relationship between oil prices and economic growth. The relationship between oil production and economic growth is, however, not bidirectional. Labour force and gross fixed capital formation also have a significant relationship with economic growth. The findings from the study show that the countries rely more on oil prices than oil production to boost economic growth. The result, however, varies across different regions.

The study is organised into five sections. The first section is the introduction, followed by the review of literature; the third section presents the methodology and data information, while the fourth section presents the results, discussion of results, and analysis, and discusses the paper and results in relation to previous studies to justify the novelty of the contribution. Section 5 concludes the paper.

2. Literature Review

We have divided the literature review into two portions: (i) oil price in relation to demand and supply, (ii) oil price and economic growth nexus.

2.1 Oil Price in Relation to Demand and Supply

Like every product, supply and demand interaction brings about shifts in oil markets. When supply is more than demand, price falls, and the opposite often occurs as demand exceeds supply. The fall in demand for oil in China and Europe fueled by OPEC's constant supply of oil led to the 2014 fall in oil prices (Mead & Stiger, 2015). Excess oil supply caused a drastic fall in the price of oil. Crude oil prices have fluctuated since 2014 and are valued at approximately $60 per barrel at the end of 2019 (U.S. EIA, 2020b).

An aggregate decline in demand raises oil prices if linked with an oil supply deficit for oil-importing economies, and its implication on the balance of non-oil supply is not clear (Kilian, 2009; Bodenstein et al., 2011). Baumeister and Kilian (2016) estimate that more than fifty percent of the fall in oil prices represents the combined impact of past oil demand and supply shocks. Furthermore, among the outstanding fifty percent, the most substantial shock was directly linked with the deteriorating global economy, even though positive oil supply shocks were confined in the third and fourth quarters of 2014.

The global economy has absorbed the increased supply of oil, aided by the occasional supply disruptions caused by the civil war afflicted Iraq and Libya or by sanctions-hit Iran. This scenario unraveled in mid-2014 when demand in Europe, Japan, and China decreased with a slowdown. China's economy has slowed as it tackles a debt overhang (IMF, 2015), and middle-income shifts to a service sector have led. Iraq and Libya were also able to supply oil to the market during this period. The excessive oil supply over the oil demand led to a sudden glut and declining prices. This was supported by Hamilton (2015), who reported that roughly half of the price decline could be attributed to the slowdown in demand. The OPEC announced no reduction in production quotas at an extraordinary meeting held in November 2014, leading to a free fall in oil prices (Chakravarty, 2015).

Following the 2018 statistics, OPEC controls nearly 80% of the world's total supply of oil[6]. The body sets output levels to meet international demand and can influence oil and gas prices by decreasing or increasing output. The U.S. started exploring shale oil, which is cheaper than conventional oil. This has brought about a rise in the supply of oil. Since the turn of 2010, the North American shale and oil sands have added over 4 MBPD to the world supply (Chakravarty, 2015). With so much oversupply of oil in the industry, a significant decline in production leads to a reduction in the overall supply, resulting in a price increase. The U.S. crude oil production has continued to increase since 2017, and as of 2019, the United States, on average, contributes about 12 million barrels of oil daily in production (U.S. EIA, 2020c).

Rafiq et al. (2016) explore the long-term asymmetric impact of oil prices on crude oil, non-oil, and total balances between 1980 and 2011 for 40 oil-importing economies and 28 oil-exporting economies. The study also noted that a fall in the price of oil has a negative effect on the importers of oil and a beneficial impact on petroleum exporters. They argued that this reflects rising oil demand as oil prices decreased.

Cashin et. al. (2014) employed sign restrictions on the generalized impulse responses of a Global VAR model which was estimated for 38 countries/regions over the period 1979

[6] OPEC. (2018). *OPEC Share of World Crude Oil Reserve 2018*. Retrieved from Organization of the Petroleum Exporting Countries: https://www.opec.org/opec_web/en/data_graphs/330.htm

to 2011, to discriminate between supply-driven and demand-driven oil-price shocks and to study the time profile of their macroeconomic effects for different countries. The results of the study indicate that the economic consequences of a supply-driven oil-price shock are very different from those of an oil-demand shock driven by global economic activity and vary for oil-importing countries compared to energy exporters. In the same vein, Kilian (2020) conducted research on the estimation of oil demand and supply elasticities using structural vector autoregression (VAR) models. The study confirms that the one-month oil supply elasticity is close to zero, suggesting that oil demand shocks have a more significant impact on the real price of oil. This solidifies the claim that the effect of demand-driven and supply-driven oil-price shocks differs. Salisu and Isah (2017) discovered that the oil-importing, oil-exporting, and stock prices of nations respond asymmetrically to oil price changes in their research work. There is a close relationship between oil trade and fluctuations in production, as Gazdar et al. (2019) concluded.

2.2 Oil Price and Economic Growth

Oil importers should enjoy more from reduced oil prices since a fall in oil prices raises households and real corporate income, similar to a tax reduction. At the same time, oil-exporting nations should profit from high oil prices. As discovered by (Rasmussen et al., 2011; WorldBank, 2013), decreasing oil prices by 10 percent could increase oil-importing economies' growth by between 0.1 and 0.5 percentage points, depending on the stake of oil imports in the country's GDP. The current accounts of the oil-importing nations may also experience significant positive changes (Kilian et al., 2009) with a varying impact that depends on oil price developments' drivers (Buetzer et al., 2012; IMF, 2005). The extent of the development benefits and structural progress relies mainly on particular country-specific circumstances. Turhan et al. (2013) find that an increase in oil prices results in currency appreciation for some developing economies like Korea, Indonesia, and the Philippines compared to the U.S. dollar. Also, fluctuations in commodity prices may adversely affect long-term development, as highly fluctuating prices may increase uncertainty which deters investment (Budina, 2007).

Abeysinghe (2001) split the influence of oil price shocks into two sub-effects: the direct effect of oil prices and the indirect effect (spillover impact) that acts across the economy's trading partners. Ftiti et al. (2016) also broke the economic influence of oil prices into two consequences. As Ftiti et al. (2016) demonstrated, the impact of oil prices on economic development has long and short-term influences on an economy's growth. However, the result was that the medium-term effects' impact is more significant than the short-term effects. According to Ftiti et al. (2016), the medium-term impact is attributed to aggregate demand-side oil price fluctuations (Chinese economic development and the global financial crisis of 2008), which triggered a far higher association. Shahbaz et al. (2017) studied the dynamics of electricity consumption, oil price, and economic growth using data from 157 countries from 1960 to 2014. The data was analyzed using the panel cointegration, long-run parameter estimation, and Pool Mean Group tests to check for the cointegration and short-run and long-run relationships between the variables. They noted that despite the oil prices, developing countries rely heavily on electricity consumption for economic growth.

Sovereign wealth funds may also contribute to reducing the damping effect of oil price fluctuations on growth by encouraging government expenditure to prevent abrupt contractions in the economy (Mohaddes & Raissi, 2017). As shown in the work of Atil et al. (2020), oil prices have a positive influence on financial performance. Du et al. (2010) found that oil prices have substantial effects on China's inflation and growth, while Fan et al. (2013) showed the short-term effect of oil price shocks on China's economy. Mallick et al. (2018) reported that high oil prices, government spending, and real interest rates have negative consequences on the output of domestic private investment, while the improvement of the financial sector, as held by Jarrett et al. (2019), international growth, and globalisation help to improve private investment.

Alimi and Aflouk (2017); Jawadi and Ftiti (2019) studies point out that a nonlinear relationship exists between oil prices and economic growth. While Alimi & Aflouk (2017) research focused on GCC (Gulf Cooperation Council) countries, Jawadi and Ftiti (2019) focused on only Saudi Arabia (Rano, 2009). Additionally, Gounder and Bartleet (2007) discovered in their findings that oil price shock and exchange-rate appreciation have a significant effect on the oil-exporting nations' real economic development. The findings of the study by Berument et al. (2010) suggest that one standard oil price deviation shock has a statistically significant and positive impact on the development of the major net oil-exporting countries: Algeria, Libya, Oman, Kuwait, Iran, Iraq, Syria, Qatar, and the United Arab Emirates. The consequences of oil prices do not significantly affect other countries' economies statistically: Egypt, Jordan, Morocco, Tunisia, Bahrain, Djibouti, and Israel.

To examine how oil price shocks influence growth in 21 nations, Taghizadeh-Hesary et al. (2019) used the simultaneous equation model with weighted minimum square estimation techniques and quarterly data from 1990 to 2015. Positive oil price changes stimulate economic development for Iran, Kazakhstan, Indonesia, the Russian Federation, and the United Arab Emirates. Positive oil price shocks decrease development for Hong Kong, China, the PRC, Japan, Singapore, the Republic of Korea, and Vietnam. Idrisov et al. (2014) attempted to reflect a theoretical understanding of oil prices' economic growth effects in the present Russian Federation. The key finding reveals that a gradual rise in oil prices could not affect the nation's long-term economic growth pace, predetermining short-term transition patterns from one long-term equilibrium to another. Using an IVAR method in his work, Bergmann (2019) shows strong significance for the presence of nonlinear moderator effects induced by a fall in the share of oil-to-energy, which undermines the causal impact of oil prices on production. Oil development drives GDP growth in Angola, Algeria, Libya, and Egypt, although not in Nigeria (Eregha & Mesagan, 2020).

Van Eyden et al. (2019) used several diverse panel data estimators ranging from fixed effects, random coefficients (R.C.s), feasible generalised least squares (FGLSs), bias-corrected least square dummy variables (LSDVCs), and generalised timing methods (GMMs) to assess the impact of real oil price fluctuations on real GDP growth for seventeen member nations of the Organization for Economic Cooperation and Development (OECD). The study's key result is that the volatility of the oil prices in the survey has a detrimental and statistically relevant effect on OECD countries' economic development. Additionally, oil-producing nations are significantly adversely influenced by oil price volatility while accounting for slope variability, most prominently in Norway and Canada. El Anshasy (2009) takes a different approach from Van Eyden et al. (2019) by examining the impact of unstable oil prices and the resulting fluctuations on government revenues on the economic growth of oil-exporting countries. The findings indicate that the volatility of oil prices does not appear to hinder long-term growth.

Djimeu and Omgba (2019) explored the factors behind the diversification of exports to oil countries. They examined the effect of oil booms on export diversification from an analytical context. The research shows that the economy's export structure before the oil boom plays a defining role in how oil windfalls can affect diversification. Consequently, the oil boom only adversely affects export diversification if the economies initially display a low degree of diversification. The oil boom will not affect the diversification of countries with a large degree of diversification prior to the boom. With a detailed study of 134 countries, these results are subject to several sensitivity analyses. The industrial sector data corroborate these assertions as it shows that when there is an oil boom in nations with a small manufacturing sector, the diversification process is slow. Nevertheless, this is not to say that oil supplies should not give rise to economic, political, or social problems. De Michelis et al. (2020) studied the effects of oil prices on consumption across countries and the United States by exploiting the time series and cross-sectional variation in oil dependency of these economies. The study showed that oil price declines generate positive effects on consumption in oil-importing economies while depressing consumption in oil-exporting economies. In the study, it was also ascertained that the increase in oil prices does more harm than good afforded by the decrease in oil prices in both the world and in the United States.

On the other hand, this study posits that oil wealth negatively affects diversification if the economy is already concentrated. On the other side, because a nation still has a bigger portfolio of export goods until the oil boom, it will consume the windfall. There are three main explanations for this assertion (see; Baland & Francois, 2000; Cherif, 2013; Cherif & Hasanov, 2014; Dunning, 2005; Omgba, 2014). Ito (2010) analysed the effect of oil price adjustments on GDP development and foreign-exchange levels in Russia from 1994 to 2009. The study used VAR's schematics. Results revealed that a one percent rise or fall in oil prices leads to 0.46% of GDP development or reduction. After oil price adjustments, the study concluded that the Russian economy is susceptible to oil price fluctuations as it increases and decreases the short-term exchange rate and inflation rate. Mukhtarov et al. (2021) investigated the influence of oil price shocks on GDP per capita, exchange rate, and total trade turnover in Azerbaijan by using the Structural Vector Autoregressive (SVAR) to analyse the collected data from 1992 to 2019. The result concludes that oil price shocks (rise in oil prices) positively affect GDP per capita and total trade turnover, whereas their influence on the exchange rate is negative. They, however, advised Azerbaijan and other oil-exporting countries to reduce its dependence of GDP per capita, total trade turnover, and exchange rate from oil and oil prices but rather diversify its dependency.

In an attempt to ensure that some possible residual endogeneity between oil prices and finance is resolved, Jarrett et al. (2019) used a cross-sectionally expanded autoregressive distributed lag model from 1980 to 2016 for thirty oil-generating nations. The test shows that with more influential financial institutions, the impact of oil fluctuations on development is mitigated. The research supported that financial development plays a decisive role in improving energy security and enhancing production.

Jawadi and Ftiti (2019) confirmed the oil sector's positive contribution to economic growth in the oil-exporting country of Saudi Arabia. This discovery does not mean that other oil-exporting countries will have the same outcome. From the various literature reviewed, many previous studies have examined the impact of oil prices on economic growth on some countries (see; Abeysinghe, 2001; Bergmann, 2019; Ftiti et al., 2016; Gazdar et al., 2019; Gounder & Bartleet, 2007; Grigoli et al., 2019; Idrisov et al., 2014; Ito, 2010; Jarrett et al., 2019; Jawadi & Ftiti, 2019; Kocaarslan et al., 2020; Mallick et al., 2018; Mo et al., 2019; Mokni, 2020; Naifar et al., 2020; Nonejad, 2020; Nusair & Olson, 2019; Rano, 2009; Salisu & Isah, 2017; Thorbecke, 2019; Van Eyden et al., 2019). Given that we are dealing with multiple countries, this research will employ panel regression data analysis to examine OPEC member countries' data from the post-global recession period of 2008 from 2010 to 2019. The decision to use panel data regression is based on previous literature, which suggests that panel regression has been used in similar studies.

3. Methodology

Model specification

To examine the empirical relationship between the crude oil price and GDP, this study adopts the Solow growth model, which is widely used in empirical studies. According to the approach adopted by Dornbusch et al. (2001), the growth accounting equation is derived as follows:

$$Y = Af(K, N) \tag{1}$$

Where Y= Economic Growth, A= Technological progress, K= Capital stock, and N= Labour.

The production function above indicates that output is a function of capital, labour, and technological progress. By letting output change in correspondence with the change in input K, N, and A multiplied by their marginal productivity, it results in Equation (2) below.

$$\Delta Y = MPN.\Delta N + MPK.\Delta K + F(KN).\Delta A \tag{2}$$

Where MPN and MPK indicate the marginal productivity of labour and capital, respectively, if equation **Error! Reference source not found.** The above is divided by equation (1), then we arrive at:

$$\frac{\Delta Y}{Y} = \frac{MPN}{Y}.\Delta N + \frac{MPK}{Y}.\Delta K + \frac{\Delta A}{A} \tag{3}$$

Multiplying and dividing the first and second parts of the RHS by N and K will give:

$$\frac{\Delta Y}{Y} = \left(\frac{MPN}{Y}N\right)\frac{\Delta N}{N} + \left(\frac{MPK}{Y}K\right)\frac{\Delta K}{K} + \frac{\Delta A}{A} \tag{4}$$

In a perfectly competitive market, factors are paid for their respective marginal product. MPN = w and MPK = r, where w and r stand for the market wage rate and net capital rental rate. Therefore, labour and capital shares are a fraction of the total payments $\frac{MPN}{Y}N$ and $\frac{MPK}{Y}K$, respectively, as shown in equation (4). Substituting labour and capital share with $1 - \alpha$ and α will give us the growth accounting equation below:

$$\frac{\Delta Y}{Y} = (1-\alpha)\frac{\Delta N}{N} + (\alpha)\frac{\Delta K}{K} + \frac{\Delta A}{A} \tag{5}$$

Equation (5) summarises that the growth of inputs and productivity in the RHS gives the output growth in the LHS.

$$y = \frac{Y}{N} \; and \; k = \frac{K}{N} \tag{6}$$

From Equation (6), y and k indicate per capita output and capital values. The growth rate of output per capita (y) equals growth in output minus the growth rate of population or labour force which also applies to the rate of growth in capital per capita as expressed below:

$$\frac{\Delta y}{y} = \frac{\Delta Y}{Y} - \frac{\Delta N}{N} \; and \; \frac{\Delta k}{k} = \frac{\Delta K}{K} - \frac{\Delta N}{N} \quad (7)$$

To transform the growth rate of output to per capita terms, then we subtract the growth of labour force or population ΔN/N from both sides of Equation (5).

$$\frac{\Delta Y}{Y} - \frac{\Delta N}{N} = \left((1-\alpha)\frac{\Delta N}{N} + \alpha\frac{\Delta K}{K} + \frac{\Delta A}{A}\right) - \frac{\Delta N}{N} \quad (8)$$

Since from equation (7) $\frac{\Delta k}{k} = \frac{\Delta K}{K} - \frac{\Delta N}{N}$, then $\frac{\Delta K}{K} = \frac{\Delta k}{k} + \frac{\Delta N}{N}$. Substituting this in Equation (8) will arrive at:

$$\frac{\Delta Y}{Y} - \frac{\Delta N}{N} = \left((1-\alpha)\frac{\Delta N}{N} + \alpha(\frac{\Delta k}{k} + \frac{\Delta N}{N}) + \frac{\Delta A}{A}\right) - \frac{\Delta N}{N} \quad (9)$$

Solving equation (9) further gives equation (10),

$$\frac{\Delta y}{y} = \alpha\frac{\Delta k}{k} + \frac{\Delta A}{A} \quad (10)$$

Equation (10) above indicates that per capita output growth is equivalent to growth in capital per capita plus the growth of total factor productivity or technological progress. From equation (10) above, the Solow growth model does not include oil price and oil production as factors of production. However, it explains that the economy is a function of capital and labour.

Recent studies (Bergmann, 2019; Fuinhas et al., 2015; Mensah et al., 2019; Mo et al., 2019; Rano, 2009; Thorbecke, 2019) on economic growth, however, show that oil production and oil prices are elements of the GDP of oil-producing nations. Broadly, their findings show that these variables are essential in influencing economic growth and development.

Therefore, this research's specified growth model is based on five variables: output growth, gross fixed capital formation, labour force, oil price, and oil production. These are in line with other literature on economic growth, as cited in equation (1).

The model for this study is thus extended as:

$$\frac{\Delta y}{y} = \beta_1 \mathrm{LABF_{it}} + \beta_2 \mathrm{GFCF_{it}} + \beta_3 \mathrm{OILPRICE_{it}} + \beta_4 \mathrm{OILPROD_{it}} + U_{\mathrm{it}} \quad (11)$$

Where $\mathrm{LABF_{it}}$, $\mathrm{GFCF_{it}}$ are representatives of labour and capital, respectively. Also, $\mathrm{OILPRICE_{it}}$ and $\mathrm{OILPROD_{it}}$ represent oil price and oil production of country *i* at time *t*. Finally, *U* represents the error term.

Labour force is an essential determinant of economic growth as the economy needs the people to function. People are required to produce goods and services, and with expansion in the economy, technology is introduced, and people are also needed to operate the technology. However, some countries, such as China, still use their growing labour force, particularly in the textile sector. Of particular importance to us is the impact oil prices have on oil-producing nations' economic growth. The April 2020 World Economic Outlook by the

IMF notes that Guyana will record the highest positive real GDP growth in 2020, which is based on the fact that oil was discovered in the country in late 2019. Exxon Mobil has begun exploring crude oil, of which the government expects $300M annually in revenue from the share of profit and royalties. This is expected to increase by more than 100 percent following a second offshore production due to commence by 2022. Cheng et al. (2019) noted that although the relationship between the cost of crude oil and the growth rate in an economy is significant, a positive relationship only exists at high frequency, while a negative relationship exists between economic growth and crude oil price at low frequencies.

Crude oil production, which the OPEC cartel members usually cap to influence the international price of their oil, also affects the economy's growth rate. This happens in the producing countries because the more significant the supply at a high price, the higher the countries' chances of experiencing real economic growth. Melike & Fazil (2013) highlight that the production of oil and economic growth are co-integrated for Eurasian economies. They further explain a positive bi-directional correlation between oil production and GDP in the short and long term, supporting the policies about investing in energy infrastructure. As mentioned earlier, the explanations justify the inclusion of oil prices and oil production as variables expected to affect the growth rate of oil-producing countries that are members of OPEC.

Econometric Approach

Fixed Effect (F.E.) Estimator and Random Effect (RE) Estimator

Fixed Effect Estimator

Though the intercept may differ for the individual variables in a panel data model, there is no time variability among each variable's intercepts. This means that each variable is time-invariant. This is referred to as a fixed effect, as shown in equation (12).

$$Y_{it} = \beta_{1i} + \beta_2 X_{2it} + \beta_3 X_{3it} + u_{it} \quad (12)$$

Therefore, dummies are advisable to avoid the dummy variable trap. Since this is so, then the literature also refers to the fixed effect as THE LSDV model (Gujarati, 1995). The fixed effects are appropriate when focusing on a specific set of N countries, such as Nigeria, Egypt, South Africa, and other countries.

Random Effect Estimator

Although the fixed effects Estimator is a straightforward method to apply, it can prove difficult in the aspect of degrees of freedom if the model has many cross-sectional units. According to Gujarati (1995), if the dummy variables do not represent the correct model, it is ideal to show this with a disturbance term u_{it}. This is where the Error Components Model (ECM) or Random Effects Model (REM) approach comes into place. Assuming an equation (13);

$$Z_{it} = \Upsilon 1_i + \Upsilon 2X2_{it} + \Upsilon 3X3_{it} + u_{it} \quad (13)$$

Rather than expressing Υ1i as fixed, we consider it a random variable with a mean value of Υ1. Furthermore, the intercept value for an individual cross-sectional unit can be stated as:

$$\Upsilon 1_i = \Upsilon 1 + \varepsilon_i = 1, 2, \ldots n \quad (14)$$

Where ε_i is a random disturbance term with a mean value of 0 and variance of σ^2_ε, we necessarily mean that the four variables included in the sample are drawn from a much larger pool of such variables. Also, they have a common mean value for the intercept (= Υ1), and the individual differences in the intercept values of each variable are shown in the disturbance term ε_i.

By substituting (14) into (13), we have the following:

$$Z_{it} = \Upsilon 1_i + \Upsilon 2X2_{it} + \Upsilon 3X3_{it} + \varepsilon_i + u_{it}b \quad (15)$$
$$= \Upsilon 1_i + \Upsilon 2X2_{it} + \Upsilon 3X3_{it} + Q_{it}$$

Where:

$$Q_{it} = \varepsilon_i + u_{it} \quad (16)$$

This, therefore, brings us to the difference between ECM and FEM. In ECM, the intercept $\Upsilon 1$ stands for the mean value of all the (cross-sectional) intercepts, and the error component εi shows the (random) deviation of the individual intercept from the mean value. In FEM, on the other hand, each cross-sectional unit has its own (fixed) intercept value in all N such values for N cross-sectional units.

Hausman Test

As a result of the OLS estimator's limitations, the Generalized Least Square (GLS) method was adopted in the analysis of the study. The Generalized Least Square method solved the serial correlation problem in panel data analysis (Wooldridge, 2012). For this study, fixed effects and random effects techniques were applied using the GLS estimator, and Hausman's test proposed by Hausman (1978) was conducted as an evaluation technique. The test identified which result (fixed or random) is statistically appropriate. In Hausman's test, the rejection of the null hypothesis means Between Estimator is inconsistent while the within Estimator is consistent; in other words, the Fixed Effect is preferred and vice versa. Thus, the relevant result will then be interpreted.

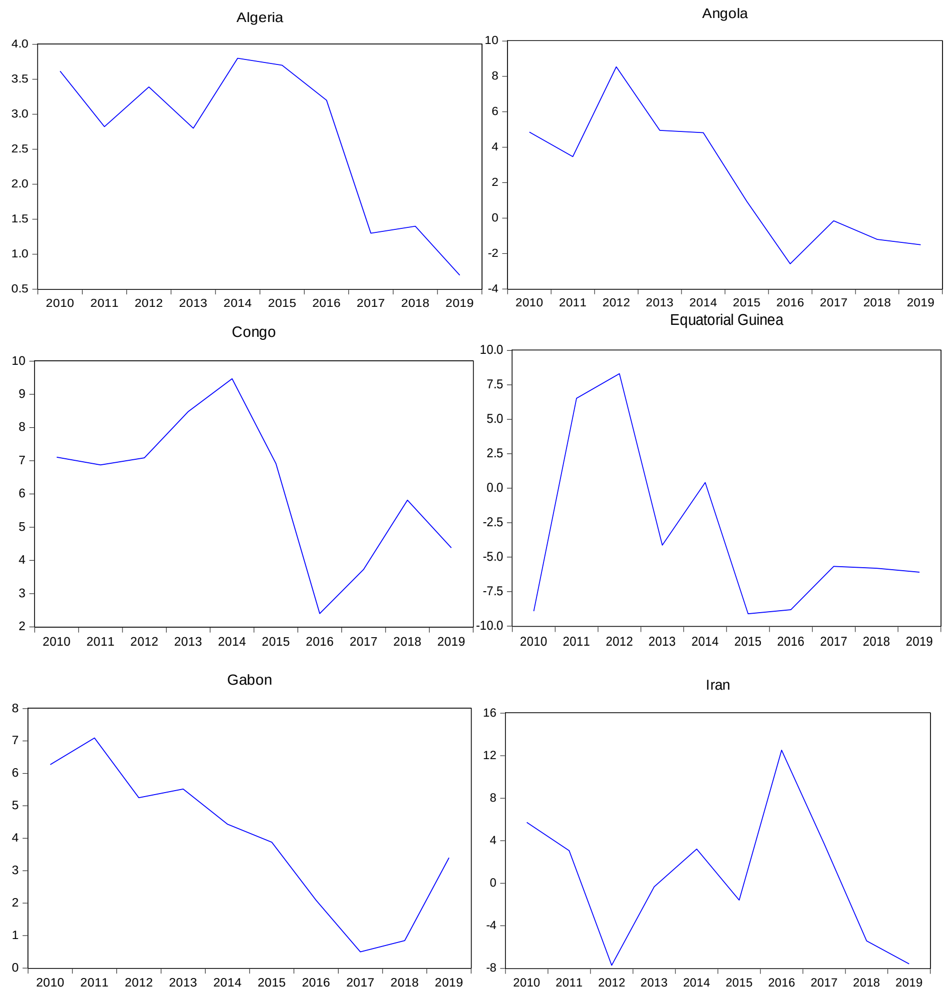
Nature and Sources of Data

The necessary variables in this analysis include the real GDP of the different countries, which serves as the dependent variable for this study, capital stock, labour, oil price, and oil production, which are the independent variables. There are 13 cross-sectional units in the data, and ten years spanning from 2010 to 2019. The 13 cross-sectional units include all the 13 OPEC members – Algeria, Angola, Congo, Equatorial Guinea, Gabon, Iran, Iraq, Nigeria, Saudi Arabia, United Arab Emirates & Venezuela. We chose 2010 because it was the period after the world got out of the global financial crisis. The study employed secondary data sourced from the International Energy Association (IEA), World Bank, and the IMF.

Real GDP is measured in National Currencies, and it is obtained from the IMF. Gross Fixed Capital Formation (GFCF) is used as a proxy for capital stock and is measured in a million dollars. Like the GCFC, the Labour force is obtained from the World Bank, and the data is measured in Units. Oil Price and Oil Production are obtained from the IEA; while the oil price is measured in dollars per barrel, oil production is measured in a million barrels per day (MBPD).

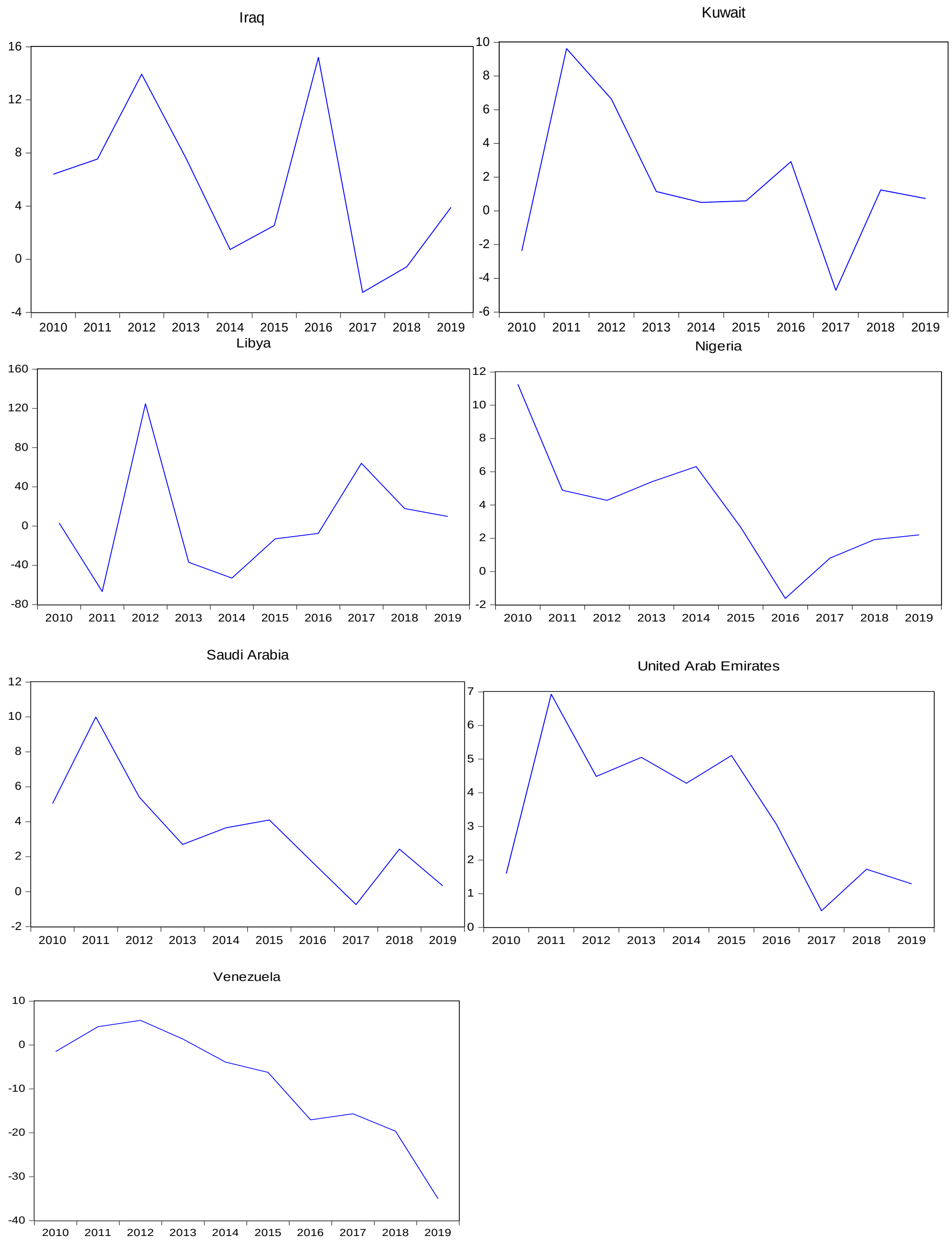
4. Empirical Results

Figure 1 shows the trend in the OPEC members' real GDP growth rate from 2010 to 2019. Table 1 summarises the descriptive statistics for the variables mentioned in the methodology for the 13 OPEC members for ten years starting from 2010 to 2019.



Source: Countries Bureau of Statistics and OPEC.

Figure 1a: Trend in Economic Growth (%) of OPEC Members



Source: Countries Bureau of Statistics and OPEC.

Figure 1b: Trend in Economic Growth (%) of OPEC Members

The trend analysis above shows that OPEC members relatively enjoyed robust economic growth after the financial crisis 2008 and just before the 2016 oil price crash. However, we observed some countries, such as Iran, Iraq, Equatorial Guinea, Libya, and Venezuela, which have been on the path of slow growth even before the oil price crash in 2016. This resulted from the country's internal crisis, like the battle of ownership of oil wells and oil-induced corruption in the countries. Since the oil price crash, OPEC members have had their growth rate fragile as most of them are yet to recover from the crash. For example, the Nigerian economy grew modestly by 0.81%, 1.92%, and 2.21% in 2017, 2018, and 2019 respectively.

Table 1 Descriptive Statistics

	GDP	**LABSTK**	**CAPSTK (USD)**	**OILPRCIE (USD/barrel)**	**OILPROD (MBPD)**
Mean	562,968.9	15,486,080	59,862.85	82.8934	2.4666
Median	6,544.679	11,437,925	61,099.01	79.61	1.7817
Maximum	694,0834	58,403,811	195,315.28	111.57	10.4207
Minimum	0.001	358,501	1,702.83	45.13	0.1312
Std. Dev.	1,754,127	15,180,126	51,380.59	25.6004	2.7061
Skewness	2.9699	1.5461	0.8731	-0.1949	1.8399
Kurtosis	9.8855	4.7312	3.0763	1.4021	5.6999
Jarque-Bera	320.4253	48.6649	11.8400	10.4819	80.7169
Sum	52,356,107	1.44E+09	5.57E+12	7,709.09	229.3977
Sum Sq. Dev.	2.83E+14	2.12E+16	2.43E+23	60,295.12	673.7208

Source: Research findings

Table 1 shows that the average labour force among the OPEC member countries is 15.49 million, while 50% of the labour force is below 11.44 million and 50% of the labour force is above 11.44 million. Nigeria has the highest labour force among the countries with total labour force amounting to 58.4 million, while Equitorial Guinea has the lowest labour force among the countries. Based on the capital stock statistics, the mean capital stock among the OPEC member countries is 59.9 million dollars. 50% of the countries have capital stock below 61.1 million dollars, while the other 50% have capital stock which is above 61.1 million dollars. Based on the oil price movement, the average oil price between 2010 and 2019 was $82.89/barrel, while the minimum oil price was $45.13/barrel which was the average price in 2016. 2012 was the highest oil price period, as oil prices averaged $111.57/barrel. In terms of oil production, Saudi Arabia produced the most oil among the OPEC member countries. In 2016, its oil production averaged 10.42 mbpd. In 2017, 2018, and 2019, Equatorial Guinea produced 0.13mbpd, 0.13mbpd, and 0.12mbpd, which was the lowest among the OPEC member countries.

With different minimum and maximum values, as well as mean and standard deviation across the observations and periods, it implies that real GDP, oil price, oil production, capital stock, and labour force among the OPEC member countries are of varying degrees, and the implication of this would be inconsistent among the countries.

The correlation matrix in Table 2 depicts that the price of oil has a negative correlation with the real GDP and labour force of the oil-producing countries, and this correlation relationship is not strong. It shows that real GDP is positively sensitive to labour force, capital stock, and oil production, with capital stock having the strongest correlation with real GDP. This underpins the importance of capital development towards the growth and development of OPEC member countries economies. Following this is the OPEC member nations' labour force and the oil production per day of the OPEC member nations. Oil price having a negative relationship with real GDP shows that relying on the oil price for growth and development of the OPEC member countries is not favorable as the economies of the countries (especially the ones that depend on the single commodity for foreign exchange) are reliant on the international fluctuation of the oil price movement. Countries such as Nigeria, Libya, and Venezuela have had more than 60% of their earnings coming from crude oil, of which low prices of crude oil usually lead to negative growth of the economies concerned.

Table 2 Correlation Matrix

	RGDP	**LABSTK**	**CAPSTK**	**OILPRCIE**	**OILPROD**
RGDP	1	0.2011	0.3477	-0.0140	0.0955
LABSTK	0.2011	1	0.2058	-0.0415	0.0063
CAPSTK	0.3477	0.2058	1	0.069168	0.8355
OILPRCIE	-0.0140	-0.0415	0.0692	1	-0.0322
OILPROD	0.0955	0.0063	0.8355	-0.0322	1

Source: Research Findings

Table 3: Unit Root Test

Variable	**At level**		**At First Difference**	
	ADF Statistics	**P-Value**	**ADF Statistics**	**P-Value**
LABSTK	0.8959	0.8126	-2.7420	0.0031***
CAPSTK	-0.4186	0.3385	-4.7047	0.0000***
OILPRICE	0.3112	0.6216	-3.0005	0.0020***
OILPROD	2.1015	0.9799	-2.0817	0.0209**

Note: ***, **, * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 3 above describes the findings from the Augmented Dickey-Fuller (ADF) unit root test at a level and at first difference. The test result shows that although none of the variables are stationary at level, they are all stationary at first difference. While LABSTK, CAPSTK, and OILPRICE are stationary at the one percent significance level, OILPROD is stationary at the five percent level of significance.

Presentation of the Model

The null hypothesis technically is that OLS and GLS are consistent, but OLS is inefficient. That is, a random effect estimator is preferred to a fixed-effect Estimator. Simultaneously, the null hypothesis technically is that OLS is consistent, but GLS is not, that is, fixed-effect Estimator is preferred to random-effect Estimator. If the value of the statistics is large, then the difference between the estimates is significant. So, we reject the null hypothesis that the random-effects model is consistent and use the fixed effects Estimator (Asteriou and Hall, 2007). The fixed-effect model is used to estimate our model as preferred by the Hausman test conducted on the selection between the fixed-effect models or the random-effect model.

Table 4 Fixed Effects Result

Fixed effects (within) regression Dependent Variable: LGDP				
Variable	**Coefficient**	**Std. Error**	**T-statistics**	**P-Value**
LCAPSTK	.2049	.0221	9.26	0.0000***
LLABSTK	.6010	.1019	5.90	0.0000***
OILPRCIE	-.0012	.0003	-3.92	0.0000***
OILPROD	.0337	.0214	1.58	0.1119
CONS	-5.7867	1.7315	-3.34	0.0001***
R-Square: 0.7256 F(4,78) = 51.57 Prob > F = 0.0000 F test that all u_i=0: F(10, 78) = 49416.53 Prob > F = 0.0000				

Source: Research Findings

Table 4 presents the regression output of the estimated model, and it can be seen that a 1% rise in capital stock will result in a 0.20% increase in the real GDP of the OPEC member countries. A 1% increase in the labour force will result in a 0.60% rise in real GDP. However, a one-dollar increase in oil price leads to a -0.001% decrease in real GDP and growth in oil production by 1mbpd leads to a 0.3% increase in real GDP. The implication of this is that real GDP is more sensitive to oil production than the fluctuation in the international price of crude oil of OPEC members. This is in line with Bashar et al. (2013), which find that higher uncertainty in oil prices significantly leads to a reduction in consumption and general prices, hence behaving like an adverse demand shock. They see that real GDP is negatively affected by uncertainty shocks to oil prices. This further explains that the OPEC member countries have been dependent on oil production to boost their economic growth because their economies have been fragile and have moved in line with oil price fluctuations. To increase the price, they tend to reduce production, which indirectly reduces the level of their economic growth.

R-square value of 0.7256 indicates that 72.56% variation in real GDP in each of the OPEC member countries is explained by the explanatory variables (LCAPSTK, LLABSTK, OILPRCIE, and OILPROD) included in the model, and this shows that the model is a good fit.

Furthermore, the probability value of the F-statistic for the model is 0.0000. Therefore, the value is lower than the 5% significance level; hence, the null hypothesis is rejected, which implies that the variables are jointly significant. The Random Effects estimation and Hausman test results are presented in the Appendix.

Our findings are in line with Bergmann (2019) and Mensah et al. (2019). With the use of the IVAR approach, Bergmann (2019) finds strong significance for nonlinear moderator effects resulting from a fall in the oil-to-energy share, which leads to a weak causal effect of oil prices on economic growth. For Mensah et al. (2019), there is a unilateral cause-and-effect relationship between oil prices to fossil fuel consumption, carbon emission, and economic growth across country groups both in the short run and in the long run. They also found a bilateral causal link between fossil fuel energy consumption and economic growth. Their result is also consistent with Fuinhas et al. (2015), as labour and capital included in their models are positive for economic growth. This is in line with our analysis, as both labour and capital have a significant and positive relationship with the oil-producing countries' economic growth.

5. Conclusion and Policy Implication

This study examines the impact of oil price on OPEC member countries' economic growth using panel data. The variables include the real GDP of the countries, gross fixed capital formation, labour force, oil price, and oil production, and were sourced from the IMF, World Bank, and ILO. Panel data analysis of fixed and random effects was used to analyze the data while using the Hausmann test to determine the appropriate method of analysis. Trend analysis of each of the countries growth rates was also shown.

In conclusion, the relationship between oil prices and the oil-producing countries' economic growth is negative. The countries are majorly dependent on crude oil. The Dutch disease has taken a toll on them. Whenever there is a shock in crude oil's international price, the countries tend to go into economic recession. Hence, it takes a long time to grow back to pre-recession growth rates. The result also shows that although oil production is positive for OPEC countries, it is not statistically significant in translating to improved economic growth. We believe this is because of the negative externalities associated with crude oil exploration in these countries. Examples include intermittent oil spillage in Nigeria, irrational and unplanned oil extraction in Iraq, political purges in Venezuela, and militant activities in Libya.

Based on the foregoing, this study recommends the following:

5.1 OPEC countries should diversify their earnings away from crude oil. This is more than just economic diversification. It specifically relates to having competitive goods and services as a source of foreign exchange more than what they currently receive from crude oil.

5.2 The countries should prioritise technological advancement more than recurrent spending whenever there is a boom in international oil prices. Improved capital formation through technological advancement will further reduce the shock that will cause the countries whenever oil prices experience a burst.

5.3 Given the significance of labour force to economic growth, as indicated by the study, OPEC countries should adopt China's growth model of taking advantage of cheap labour to drive manufacturing output. Brain exports are also an advantage of properly structured labour in terms of foreign currency inflows to countries. These can help in the diversification efforts of the countries and improve their medium-term growth prospects.

Compliance with Ethical Standards:

Conflict of Interest: All the authors declare that there is no conflict of interest.

Ethical approval: This article does not contain any studies with human participants or animals performed by any authors.

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