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Non-Renewable Energy Consumption and Economic Growth in Organization of Petroleum Exporting Countries

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ABSTRACT: - The aim of this study is to investigate the impact of non-renewable energy (NRE) on economic growth in selected Organization of Petroleum Exporting Countries (OPEC). Secondary data sourced obtained from IEA, WDI, and OPEC database for data between 2014 and 2022 were utilized in this study. The variables employed in this study are RGDP (proxy for economic growth), Non-renewable energy (NRE) and Global competitiveness indicator (GCI). In order to address issues of endogeneity across the OPEC this paper utilized a difference generalized method of moment (GMM) (N>T) and established that NRE is a positive and significant enabler of economic growth in OPEC. On the other hand, the result showed that the global competitiveness Index has a negative impact on economic growth in OPEC. The paper therefore concluded that NRE although a contributor to greenhouse gas (GHG) provides revenue for fiscal operations and is a supplier of cost-effective energy for industry that in turn stimulates economic growth in OPEC. In conclusion, this paper submitted that NRE is a significant enabler of economic growth in OPEC. This study therefore recommended that OPEC should utilize gradual approach in achieving its energy diversification and transition policy since NRE has a robust role in enabling growth in the region.

Keywords: Economic Growth, NREC, Difference GMM

I. INTRODUCTION

Zafar *et al.* (2019) admits that energy in any form is imperative for boosting growth. One major sources of energy globally employed to drive economic growth and development is non-renewable energy. The consumption of non-renewable energy remains a crucial energy requirement for the industrial and household energy demand for developing countries which in turn enables production, consumption, and distribution which in turn facilitate economic growth. Smil (2017) argued that NRE is a reliable source of energy. Non-renewable energy sources, such as fossil fuels, exhibit high energy density, allowing for efficient storage and transportation (Tester, et al. 2005). NRE also enables energy supply as well as other sectors which in turn helps in stimulating national economies, providing employment, and supporting various sectors (Barnes, *et al.* 2006). One argument for NRE is that it contributes to energy security (Yergin, 2006). NRE consumption has been a major source of global geopolitical tensions (Klare, 2001). Kahia, Aissa and Lanouar (2017) contend that the feedback hypothesis premises the nexus between NRE and economic growth. Le, Chang, and Park (2020) observed that NRE enables economic growth in 102 countries. Kahia *et al.* (2016) asserted that NRE supports GDP for Middle East North Africa (MENA).

Conversely, scholars such as Apergis and Payne (2010) used FMOLS and panel causality specifications to emphasize that the use of coal adversely affects development in emerging economies. The impact of NRE on growth among leading oil producers in Africa between 1980 and 2015 revealed an asymmetric effect of the former on economic growth and CO2 emission in all nations under analysis, except Algeria (Awodumi & Adewuyi, 2020). Findings from the study emphasized that in Nigeria; positive changes in NRE consumption hinder growth and dilute CO2 emissions. In Gabon, an increase in NRE consumption sustains growth and environmental health. In the case of Egypt, the consumption of NRE types has no substantial inferences on environmental quality as it enables higher rates of growth. For Angola, positive changes in NRE consumption led to better economic growth, although the impact on emissions is mixed across time and fuel type. Thus, it is imperative for policymakers in African oil-producing states to examine ways to promote non-renewable energy consumption (NREC) technologies in the quest for growth. Based on heterogeneous panel data analysis, other studies explored the nexus of Renewable Energy consumption (REC) and growth for E-7 (China, India, Brazil, Mexico, Russia, Indonesia, and Turkey) countries between 1992 and 2012 and pointed out a long-run connection among GDP, REC use, and other variables. Economic growth, the main target of all states, has led to considerable academic research exploring the impact of RE and NRE on it. Zafar et al. (2019) disaggregated energy, e.g., RE consumption and NRE consumption, and used a second-generation panel unit root test applied to Asia-Pacific Economic Cooperation states during 1990–2015 to inspect the long-term nexus between energy consumption (EC) and growth. The findings showed the positive effect of EC, both REC and NREC, on economic growth. Besides, the time-series individual country analysis also indicated a stimulating role of RE and NRE on growth. Moreover, the heterogeneous causality analysis identified a feedback effect among growth, REC, and NREC use. This empirical evidence highlights the rationale why OPEC still invests in NRE despite its quest for energy transition to RE consumption.

However, due to the issues of recalcitrant energy crises, and the climate change challenges, the OPEC government is devising ways to achieve sustainable development goals (SDGs) as well as achieving net-zero emissions targets by accepting the cut-back policy on NRE production and use. In the midst of the growing rationalization for cut-back on NRE consumption, the motivating question becomes does recent evidence support the impact of NRE consumption on economic growth in OPEC? Hence, the research interest of this paper is to contribute to the literature by estimating the impact of NRE consumption on economic growth in selected OPEC such as Nigeria, Saudi Arabia, Iran, Libya, Iraq, Kuwait, United Arab Emirates (UAE), Algeria, Venezuela, and Congo.

This paper is sub-divided into Introduction, Literature Review, Methodology, Discussion of Findings, and Conclusion and Recommendations.

II. LITERATURE REVIEW

2.1 Theoretical Framework

Endogenous growth theory is an economic theory that confronts the traditional neoclassical growth models by accentuating the role of internal factors, particularly innovation and human capital, in driving sustained economic growth (Lucas, 1988). Unlike exogenous growth theories, which attribute economic growth primarily to external factors such as capital accumulation or technological progress beyond a country's control, endogenous growth theory suggests that growth is influenced by factors within the economic system (Solow, 1956). According to Lucas (1988) human capital accumulation is a key determinant of economic growth. Investments in education, training, and skill development contribute to increased productivity and innovation. Romer (1990) asserted that technological progress and innovation enables growth through investments in research and development (R&D) and the accumulation of knowledge lead to technological progress, fostering productivity gains and sustained growth. Another crucial tenet in endogenous theory is the incorporating of the idea on positive externalities and knowledge spillovers that enable firms enjoy competitiveness because of their linkages with multinational corporations (MNC) (Grossman & Helpman, 1991). Endogenous theory contends that there is the presence of increasing returns to scale. The theory introduces the concept of increasing returns to scale, suggesting that as the economy grows the returns on capital and knowledge accumulation also increase. This dynamic process can lead to self-sustaining growth over time (Romer, 1986). Endogenous growth models underline the role of education and learning by doing in enhancing human capital and technological capabilities. Continuous learning and skill development contribute to a more innovative and productive workforce (Arrow, 1962). Endogenous growth theory has significantly influenced discussions on economic development and policy, providing a framework that emphasizes the active role of individuals, firms, and governments in driving economic progress.

Barro (1997) argued that the assumption of infinite returns and increasing returns in endogenous growth models is unrealistic. In reality, there are limitations to the extent of increasing returns, and diminishing returns may set in as the scale of production or knowledge accumulation expands. Acemoglu, Johnson and Robinson (2005) contend that the endogenous growth theory tends to underemphasize or downplay the role of institutions and policy frameworks in fostering economic growth. Effective institutions and sound policies are seen as critical for creating an environment conducive to innovation and investment. Mankiw, Romer and Weil (1992) question the theory's applicability across different countries, suggesting that heterogeneity in initial conditions and institutional structures may lead to varying growth outcomes. Some argue that the assumption of convergence among countries may not hold. On the empirical ground, endogenous growth theory has been subject of contention. Jones (1995) point out that empirical testing of endogenous growth models can be challenging, and the results may not consistently support the theoretical predictions. The complexities of real-world data make it difficult to establish clear causal relationships. Barro (2001) attests that causal relationship between factors such as education, innovation, and economic growth is complex and bidirectional. Hence, argued that while these factors contribute to growth, economic growth itself may also lead to increased investments in education and research. Issues of endogeneity such as human capital and innovation are endogenous to the model. Benhabib and Spiegel (1994) argued that this endogeneity might lead to simultaneity bias and complicate the interpretation of causal relationships. Another criticism of the endogenous growth theory is that the theory oversimplified technological progress. Aghion and Howitt (1992) question the assumption that economic agents exhibit homogeneous behavior in their pursuit of knowledge and innovation. Variations in individual and firm behavior may lead to different growth outcomes. Other criticism includes that endogenous growth theory neglect the impact of distributional effects (Galor & Moav, 2004), problems of inadequate treatment of R&D Spillovers (Peretto, 1998), inability to capture environmental sustainability concerns (Grossman & Krueger, 1995).

Aghion et al., (2016) posited that endogenous growth theory emphasizes the role of innovation and technological progress in driving economic development. In the context of energy diversification, this can be applied to the development and adoption of cleaner energy technologies, such as renewable energy sources (solar, wind, and hydropower) and advanced energy storage systems. Also, endogenous growth model is imperative for energy diversification because policies promoting R&D in clean energy technologies can accelerate the transition away from fossil fuels (Acemoglu, et al. 2012). Endogenous growth theory suggests that well-designed policies and market incentives can play a crucial role in directing technological change. In the energy sector, policies such as carbon pricing, renewable energy mandates, and subsidies can influence the trajectory of energy diversification (Goulder & Schneider, 1999). Furthermore, the concept of dynamic increasing returns in endogenous growth models implies that as the use of clean energy technologies increases, the costs of these technologies may decrease, making them more economically competitive. This positive feedback loop can drive further adoption and diversification (Romer, 1986). Endogenous growth theory can be applied to emphasize the role of innovation in addressing environmental challenges associated with conventional energy sources. Endogenous growth models recognize the path dependence of technological change. In the context of energy diversification, this implies that early investments and policies can shape the trajectory of the energy sector, potentially leading to lock-in effects that influence future energy choices (David, 1985). The learning-by-doing concept in endogenous growth theory suggests that the more a technology is used, the more efficient and cost-effective it becomes. This can be applied to the deployment and scaling up of clean energy technologies (Arrow, 1962).

2.2 Empirical Review

Destek and Sinha (2020) in a paper titled renewable, non-renewable energy consumption, economic growth, trade openness, and ecological footprint: evidence from organization for economic Co-operation and development countries examined the relationship of RE and NRE consumption, trade openness, economic growth, and ecological footprint in OECD countries. In order to examine the validity of Environmental Kuznets Curve (EKC) hypothesis with more reliable environment indicator. The paper used ecological footprint as a dependent variable and used real income per capita, renewable energy consumption per capita, non-renewable energy consumption per capita and trade openness as an independent variables in the presence of RE and NRE consumption. They found a U-shaped association connecting economic growth and ecological footprint. They also concluded that an increase in RE consumption reduces ecological footprint and safeguard environment. Therefore, the cross-sectional dependence test and heterogeneity test validate the applicability of second-generation panel models. Unit root tests indicate that the variables are first-order integrated and cointegration tests and divulge the long-run association among the variables. The panel-based empirical findings illustrate that U-shaped association persists between real GDP and ecological footprint, and therefore, EKC hypothesis does not hold in OECD countries. According to the time series-based empirical findings, the study found the evidence for the presence of EKC only in eight countries, i.e., Chile, France, Germany, Mexico, New Zealand, 3 Portugal, Turkey, and the UK. For the remaining 16 countries, there is U-shaped relationship 4 between real income per capita and ecological footprint, and therefore, EKC hypothesis does not hold in these countries.

Ivanovski, Hailemariam and Smyth (n.d.) in a study captioned the effect of renewable and non-renewable energy consumption on economic growth: Non-parametric evidence: employed the specific nonparametric method in the local linear dummy variable estimation (LLDVE) method and applied to OECD and non-OECD panels for the period 1990 to 2015. While previous studies employing parametric models have recognized the existence of non-linearity and instability in the relationship between renewable and non-renewable energy consumption and economic growth. the LLDVE method has the advantage that it does not make any assumptions about functional form and, hence, it is better able to approximate the non-linear relationship. The estimates suggest that non-renewable energy consumption exerts a positive and significant impact on economic growth across OECD nations with the coefficient function exhibiting an upward trajectory over time, while the impact of renewable energy consumption on economic growth, in non-OECD countries, however, is statistically indistinguishable from zero in these countries for most of the study period. Both renewable and non-renewable energy consumption promote economic growth in non-OECD countries.

Kahia, Aissa and Lanouar (2017) renewable and non-renewable energy use - economic growth nexus: the case of MENA net oil importing countries for the period 1980–2012. A multivariate panel framework was used to estimate the long run relationship and the panel Granger causality tests was employed to assess the causality direction among variables. The empirical results provide evidence for long-term equilibrium relationship between real Gross Domestic Product (RGDP), renewable energy use, non-renewable energy use, real gross fixed capital formation and labor force. The results provide evidence also for positive and statistically significant elasticities. Moreover, the empirical findings from panel Error Correction Model confirm the existence of bidirectional causality between renewable energy use and economic growth, and between non-renewable energy use and economic growth, results that support the feedback hypothesis. Moreover, the empirical findings provide evidence for two way (bidirectional) causal association in both the short and long-run between renewable and non-renewable energy use which proves the substitutability and interdependence between these two types of energy sources.

Le, Chang and Park (2020) in a study titled renewable and non-renewable energy consumption, economic growth, and emissions- international evidence: analyzed 102 countries, from 1996 to 2012. The effects of renewable energy and non-renewable energy sources were distinctively interrogated. The consumption of both renewable and non-renewable energy appears to have contributed significantly to the level of income across countries, implying that promoting renewable and non-renewable energy benefit economic development. The empirical evidence suggests that the use of non-renewable energy consumption significantly raised the level of emissions across different income groups of countries. On the other hand, the study found that the use of renewable energy sources helped tackle emissions in developed countries but not in developing countries. The success of developed countries in controlling emissions through renewable energy has significant policy implications for developing countries. In conclusion, first, the consumption of both renewable and non-renewable energy appears to promote economic growth for both developed and developing economies. While this evidence is found in several studies in the literature, almost no study uses a global sample (of 102 countries) like the one used here. Second, this study finds that renewable energy helped developed countries contain carbon emissions. In other words, renewable energy has been effective for controlling carbon emissions in developed countries.

Asif, Bashir, and Khan (2021) in a paper tilted the Impact of non-renewable and renewable energy consumption on economic growth- evidence from income and regional groups of countries: employed a panel data for 99 world countries with energy inclusive production function and then finding the empirical evidence for income and regional classification of world economies. The study employed panel estimation techniques to analyze the data through dynamic and fully modified ordinary least square and fixed effects model channels after confirming Hausman test over the period of 1995–2017. The study found that the impact of non-renewable and renewable energy consumption on economic growth is significantly positive while this relationship of energy-growth varies at income and regional classification. To incorporate the omitted variable biasness, capital and labor were included in the model. Thus, it is evident from the results that in the presence of non-renewable and renewable energy consumption, capital and labor have significant positive impact on economic growth. The study concluded that although energy consumption has a vital importance in boosting growth and development of the economies it recognized that non-renewable energy consumption causes environmental problems, therefore, it suggested moderate use while encouraging more of renewable energy consumption.

For oil-importing MENA states, Kahia et al. (2017) in a paper titled Renewable and non-renewable energy use and economic growth nexus: the case of MENA net oil importing countries asserted a positive and significant impact of NRE and RE on their GDP. Rahman and Velayutham (2020) in a paper titled renewable and non-renewable energy consumption-economic growth nexus- new evidence from South Asia (16 Asian countries): employed FMOLS techniques and found energy and growth relationship. Zafar et al. (2019) in a paper titled from non-renewable to renewable energy and its impact on economic growth: the role of research & development expenditures in Asia-Pacific Economic Cooperation countries also stated that energy in any form is imperative for boosting growth. Kahia et al. (2016) in a paper titled Impact of renewable and non-renewable energy consumption on economic growth: new evidence from the MENA net oil exporting countries (NOE) found a positive impact of RE and NRE consumptions on GDP for MENA oil exporting countries but NRE consumption has greater impact. Al-Mulali et al. (2014) in a paper titled Electricity consumption from renewable and non-renewable sources and economic growth-evidence from Latin American countries: found a significant role of electricity being produced by both NRE and RE sources to promote growth and development in Latin American countries.

Pao and Tsai (2010) in a paper titled CO2 emission, energy consumption and economic growth in BRICS countries asserted that total energy has positive impact on BRIC countries' growth. A multi-country study on six Central American economies by Apergis and Payne (2009) in a paper titled Energy consumption and economic growth in Central America: evidence from a panel cointegration and error correction model over the period 1980–2004 provided the evidence supportive of growth being positively affected by energy consumption. Stern (2011) in a paper titled the role of energy in economy reviewed mainstream, resource economics, and ecological economics models of growth. The study presented synthesis of energy-based and mainstream models. The study employed Vector Autoregression model test to investigate the variables and showed that energy and GDP cointegrated. It also showed that energy use Granger causes GDP when capital and other production inputs are included in the vector Autoregression model. However, various mechanisms can weaken the link between energy and growth. The study asserted that the decline of energy used per unit of economic output in developed and some developing countries is attributed to technological change and a shift from poorer quality fuels, such as coal, to the use of higher quality fuels, especially electricity. Substitution of other inputs for energy and sectoral shifts in economic activity play smaller roles. Shenggang et al. (2014) estimated the CO2 emissions related to China's international trade using an input–output analysis. Based on industrial panel data, their findings suggest that trade surplus and large FDI are the important reasons for the rapid rise of CO2 emissions in China. Shahbaz and Lean (2012) assessed the relationship between energy consumption, financial development, economic growth, industrialization, and urbanization in Tunisia. Long-run bidirectional causality was found between industrialization and energy consumption. Along with other control variables, the role of industrialization for economic growth was emphasized. Nasreen and Anwar (2014), and Shahbaz et al. (2014) also documented similar conclusions.

Dogan (2014) investigated the causal relationship between energy consumption and economic growth in the case of four low-income countries of Sub-Saharan Africa. The Granger causality test indicated unidirectional causality from energy use to economic growth in Kenya and no causality relationship for Benin, Congo, or Zimbabwe. Osigwe and Arawomo (2015) examined the causality relationships between energy consumption, oil price and economic growth in Nigeria. Their findings reflect that bidirectional causality exists between energy consumption and economic growth. AlMulali and Sab (2012) examined the role of energy in the form of increasing energy efficiency, implementing energy saving projects, energy conservation, and energy infrastructure in fostering financial development in Sub-Saharan African countries. George and Nickoloas (2011) found that there is no causality between energy consumption and economic growth and thus policies that are aimed at conserving energy will not retard economic growth. One puzzling results in the literature on energy consumption-economic growth causality is the variability of results particularly across sample periods, sample sizes, and model specification. In order to overcome these issues Balcilar et. al. (2010) analyzed the bi-directional causal links between energy consumption and economic growth for G-7 countries using bootstrap Granger non-causality tests with fixed size rolling subsamples. Ouédraogo (2010) established the directional of causality between electricity consumption and economic growth in Burkina Faso for the period 1968-2003. Alam et. al. (2011) investigated the causality relationships among energy consumption, carbon dioxide (CO2) emissions and income in India using a dynamic modeling approach. Alam et. al., (2012) investigated the possible existence of dynamic causality between energy consumption, electricity consumption, carbon emissions and economic growth in Bangladesh. Ajmi et. al. (2015) using a novel approach that may detect causalities when the time-constant hypothesis is rejected and find significant time-varying Granger causalities among the variables under consideration. Chontanawat et. al. (2008) and Lianos et al. (2022) dealt with reverse causality. Both studies examined the effects of energy consumption and carbon emissions on per capita economic growth with unbalanced panel data for 94 countries between 1971 and 2018. They assessed the effects using the potential dynamic outcomes under a framework of treatment-based causality framework. The results showed that the processing range that produces the best efficiency for both energy consumption and carbon emission policies is between −2% and 0.4%. In addition, in both cases, extreme policies such as drastically reducing or increasing energy consumption produce the worst results for economic growth.

Eggoh, Bangake and Rault (2011) in a paper titled energy consumption and economic growth revisited in African countries studied 21 African countries over the period from 1970 to 2006, employed panel unit root tests, Pedroni (1999) and Westerlund (2006, 2007) panel cointegration and causality tests. The countries were divided into two groups: net energy importers and net energy exporters. It was found that there exists a long-run equilibrium relationship between energy consumption, real GDP, prices, labor and capital for each group of countries as well as for the whole set of countries. This result is robust to possible cross-country dependence and still holds when allowing for multiple endogenous structural breaks, which can differ among countries. Furthermore, the study found that decreasing energy consumption decreases growth and vice versa, and that increasing energy consumption increases growth, and vice versa, and that this applies for both energy exporters and importers. The study concluded that there is a marked difference in the cointegration relationship when country groups are considered.

Siddiquiin (2004) in a paper titled energy and economic growth in Pakistan followed Moroney (1992) and Stern and Cleveland (2003) utilized production function framework based on Vector Auto Regression

(VAR), Error Correction Model (ECM) or Autoregressive Distributed Lag Model. The data is a time series data for period 1970– 2003. The study showed that growth in capital stock, in electricity consumption and in petroleum products affects economic growth significantly. For the natural gas, the effect of rise in consumption does not affect economic growth. The results for causality show that there is a long run relationship between growth in capital-per-worker, and productivity growth. Except for growth in human capital and consumption of natural gas, all other variables are important and statistically significant determinants of productivity growth. The estimated productivity model shows that growth in capital-labour ratio is the major determinant of productivity growth. For the remaining variables also, the results are similar to the output-growth model. Export growth contributes to productivity growth positively. Growth in electricity use per worker and petroleum products use per worker also contributes to productivity growth significantly. Interestingly, like the earlier model, the inclusion of energy in the growth model reduces the magnitude of the coefficient of growth of capital-labour ratio whereas the magnitude of the coefficient of export growth is robust. If the constant represents the impact of changes in technology, the coefficient represents insignificant impact on productivity growth, but the size of the coefficient is sensitive to the inclusion/exclusion of indicators of energy. These results indicate that capital stock is the most important determinant of economic growth. However, the coefficient is sensitive to inclusion/exclusion of the growth rate of energy sources, like electricity and petroleum products. This result implied an existence of an interrelationship between energy use and use of capital stock. Surprisingly, the effect of growth of human capital is not statistically significant. The impact of export growth is positive, and the coefficient is robust, indicating that external economic environment or openness plays a critical role in domestic economic expansion. The results show that energy is an important contributor to productivity growth.

III. METHOD OF STUDY

This study adopts a Difference Generalized Method of Moment (GMM). The merit of difference GMM stems from the fact that its model structure helps to resolve issues of endogeneity in the cross-section. Endogeneity arises when explanatory variables are correlated with the error term, leading to biased and inconsistent estimates. Difference GMM effectively deals with endogeneity by using lagged values of variables as instruments. For example, in a panel data setting where past values of variables influence current values, Difference GMM uses these past values as control for endogeneity. Another reason for the use of GMM (difference) is that unobserved heterogeneity refers to individual-specific effects that are not captured by observed variables. Difference GMM eliminates these effects by differencing the data. In a panel dataset, the regional effect, or differences in the institutional control in the management and control of the oil sector firms, are removed by differencing, allowing for a cleaner estimation of the impact of observed variables. Also, the incidence of autocorrelation occurs when error terms are correlated over time. Difference GMM can handle autocorrelation by appropriately choosing instruments. GMM uses lagged values as instruments to address this. Therefore, by using a larger set of instruments, Difference GMM can improve the efficiency of estimates compared to simpler methods. Furthermore, difference GMM is well-suited for dynamic panel data models where past values of the dependent variable influence current values. In a model studying the impact of energy consumption on economic growth, past growth rates influence current growth rates, making Difference GMM a suitable estimation method. Conversely, the demerit of difference GMM is that using too many instruments can lead to overfitting and weak identification, where the instruments are too numerous and too weakly correlated with the endogenous variables. Thus, in a longitudinal dataset with many time periods, the number of instruments can grow rapidly, making the estimation less reliable. Also, if the instruments used are weak, meaning they are poorly correlated with the endogenous variables, the estimates can be biased and inconsistent. The use of lagged levels of highly persistent variables may not be strong instruments for their different counterparts.

$$RGDP_{it} = \alpha RGDP_{it-1} + \beta_1 NREC_{it} + \beta_2 GCI_{it} + \beta_3 NREC_{it-1} + \beta_4 GCI_{it-1} + \varepsilon_{it} \quad (1)$$

Instrument Variables are: $NREC_{t-1}$ and $RGDP_{t-1}$

To rationalize the effect of Non-renewable energy consumption on economic growth in OPEC, this study utilizes difference GMM model. Difference GMM following Arrellano and Bond (1991) was utilized to estimate the effect of energy consumption on economic growth (proxy by RGDP). in this case N>T, where the number of OPEC (N) is more than time (T) (2014-2022). Based on Hausman Test, the random effect model was utilized. Thus, the *Zt* is used as global competitiveness index, Δ is difference GMM, endogenous regressors is uncorrelated with ε_{it} (COV $(ED, \varepsilon_{it}) \neq 0$. This study selected difference GMM over system GMM based on the AR (-2) autocorrelation coefficients outcome of the various models. Thus, the corresponding difference GMM models become:

$$\Delta RGDP_{it} = \alpha \Delta RGDP_{it-1} + \beta_1 \Delta NREC_{it} + \beta_2 \Delta GCI_{it} + \beta_3 \Delta NREC_{it-1} + \beta_4 \Delta GCI_{it-1} + \Delta\varepsilon_{it} \quad (2)$$

Where, RGDP is real Gross Domestic Product, non-renewable energy consumption (NREC) (proxy by fossil-fuel), and GCI is global competitiveness index (is proxy to support labour and capital in endogenous growth theory).

3.1 Presentation of Result

Table 1 provides information on the ADF Fisher Chi-square unit root test for panel data. The result showed that the data are both *I*(0) at levels and *I*(1) at first difference. The purpose of this test is to avoid spurious and misleading result, hence the imperative of this test. Fulfilling these preconditions, the econometric test is predicated on the unit root test.

Table 1: ADF Fisher Chi-square Unit Root Test

Variables	At levels	First Differencing	Conclusion
GCI	11.4250 (0.9344)	28.8622 (0.0405)	*I*(1)
NREC (fossil Fuel)	26.0831 (0.1631)	47.1305 (0.0006)	*I*(1)
RGDP	16.5619 (0.6812)	35.7828 (0.0163)	*I*(1)

Source: Author's computations from EViews 10

In panel study, cross-section dependence test (see Table 2) is required to determine the correlation. Additionally, over and above the unit root test, before utilizing these variables, it is pertinent to determine whether the variables in OPEC are correlated. This condition is necessary for panel data. Using the Pesaran CD the results in Table 2 connotes that H_1 is accepted. Thus, therefore accepting H_1 implies that there is cross sectional dependence amongst the variables which meets the conditions for panel study.

Table 2: Pesaran CD Cross section dependence Test

Variables	Cross Section dependence test	Conclusion
RGDP, NREC (fossil fuel), and GCI	1.382103 (0.0069)	Reject H_0 Accept H_1: There is cross section

Source: Author's computations from EViews 10

IV. DISCUSSION OF FINDINGS

Based on the P-values of the Hausman test in Table 3 given as 0.9978 which is more than 5%, this study accept the null hypothesis which states that random effect model is appropriate in this study. Hence, the study utilized random effect model.

Table 3: Hausman Test

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	0.004357	2	0.9978

** WARNING: robust standard errors may not be consistent with assumptions of Hausman test variance calculation.

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
NREC__FF_	-1866886626717	-984259866.	139520868191908540000	0.9538

	.396904	537376	
	16247959468162903231072284668386101		
GCI	76.2024	0.7000	4500000000000.9937

Cross-section random effects test equation:
Dependent Variable: RGDP
Method: Panel Least Squares
Date: 06/26/24 Time: 00:48
Sample: 2014 2022
Periods included: 9
Cross-sections included: 10
Total panel (balanced) observations: 90
White period standard errors & covariance (d.f. corrected)
WARNING: estimated coefficient covariance matrix is of reduced rank

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.47E+15	8.22E+13	17.94267	0.0000
NREC__FF_	-1.87E+10	2.91E+10	-0.640607	0.5237
GCI	1.62E+12	1.70E+12	0.958261	0.3409

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.996984	Mean dependent var	1.48E+15
Adjusted R-squared	0.996558	S.D. dependent var	4.36E+15
S.E. of regression	2.56E+14	Akaike info criterion	69.31182
Sum squared resid	5.10E+30	Schwarz criterion	69.64512
Log likelihood	-3107.032	Hannan-Quinn criter.	69.44623
F-statistic	2343.729	Durbin-Watson stat	0.662064
Prob(F-statistic)	0.000000		

Source: EViews 10

Table 4: Difference GMM

Dependent Variable: RGDP
Method: Panel Generalized Method of Moments
Transformation: First Differences
Date: 06/26/24 Time: 01:57
Sample (adjusted): 2016 2022
Periods included: 7
Cross-sections included: 10
Total panel (balanced) observations: 70
White period instrument weighting matrix
White period standard errors & covariance (d.f. corrected)
Instrument specification: @DYN(RGDP,-2) HHI(-1)
Constant added to instrument list

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RGDP(-1)	0.824311	2.14E-05	38487.39	0.0000
NREC__FF_	1.36E+09	20909788	65.01303	0.0000
GCI	-6.60E+11	5.29E+09	-124.7707	0.0000

Effects Specification

Cross-section fixed (first differences)

Mean dependent var	3.73E+13	S.D. dependent var	1.99E+14
S.E. of regression	2.20E+14	Sum squared resid	3.25E+30
J-statistic	5.137974	Instrument rank	7
Prob(J-statistic)	0.273431		

Source: EViews 10

Table 5: Arellano-Bond Serial Correlation Test

Equation: Untitled
Date: 06/26/24 Time: 01:58
Sample: 2014 2022
Included observations: 70

Test order	m-Statistic	rho	SE(rho)	Prob.
AR(1)	-1.003210	#######	#######	0.3158
AR(2)	-1.002356	#######	#######	0.3162

Source: EViews 10

Firstly, the result in Table 4 shows that the coefficient 0.824311 (82.4%) indicates a strong positive impact of past (lag) Real GDP on current economic growth. The positive sign means that higher Real GDP in the previous period is associated with higher economic growth in the current period. A coefficient of 82.4 % suggests that lag real RGDP is highly persistent. If the economy grew in the previous period, it is likely to continue growing in the current period. On the other hand, the result implies a drive effect where past economic performance strongly influences current performance. This can be due to factors such as investment cycles, consumption patterns, and business confidence. Therefore, high persistence can indicate stability in economic growth, but it also means that any shocks to the economy may have prolonged effects. Secondly, non-renewable energy consumption (a proxy for fossil fuel) has a coefficient of 1.36×109 is very large, indicating a substantial positive impact of non-renewable resources (fossil fuel) on economic growth. Thus a 1% change in the consumption of NRE leads to 1.36×109rise in economic growth in OPEC. The positive sign means that an increase in the production or revenue from non-renewable resources is associated with higher economic growth. Therefore, the large positive coefficient of NRE underscores the heavy dependence of OPEC countries on non-renewable resources for economic growth. Also, the result implies that Non-renewable energy consumption contributes significantly to government revenues, which can be used for investments in infrastructure, education, and other growth-promoting sectors. Conversely, NRE is subjected to volatility and oil price shock leads to energy insecurity and crises which implies that NRE is highly sensitive to fluctuations. Despite, positive NRE, the apriori expectation of fossil fuel has mixed results based on resource revenues and long-term economic growth questions. Thirdly, the coefficient of the Global Competitiveness Index (GCI) Coefficient of −6.60×1011 in Table 4 implies that is very large and negative, indicating a strong inverse relationship between global competitiveness and economic growth in this context. The negative sign suggests that higher scores on the Global Competitiveness Index are associated with lower economic growth in OPEC countries. The negative coefficient might reflect the "resource curse," where higher competitiveness does not translate into growth due to over-reliance on natural resources. The negative coefficient of the GCI indicates that simply being competitive, especially in a resource-heavy context, does not necessarily lead to economic growth. This suggests the need for a more balanced and diversified economic strategy. In Table 5, the J-statistic's p-value of 0.273431 implies that the null hypothesis of over-identifying restrictions is not rejected. This supports the validity of the dynamic panel model specification. So, therefore, *AR* (2) p-value equals 0.3162 which connotes no evidence of second-order serial correlation (see Table 5).

V. CONCLUSION AND RECOMMENDATION

This study concluded that the consumption of NRE matter in stimulating economic growth in OPEC. Hence any perceptible transition from NRE to RE in OPEC must consider the NRE and economic growth trade-off. The transition from the consumption of NRE to cleaner energy should be strategically implemented to accommodate the social and economic factors in the member countries in OPEC. From the results, the study established that NRE (proxy by fossil-fuel) is a determinant of economic growth in OPEC. This is because the consumption of NRE enables productivity and productivity accelerates economic activities which eventually lead to economic growth. Based on the results, OPEC should adopt a gradual process in its energy transition policy shift from NRE to RE in order to achieve energy security.

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