ECONOMIC GROWTH AND SUSTAINABILITY IN AFRICAN OIL-EXPORTING COUNTRIES: A DYNAMIC PANEL ANALYSIS OF RESOURCES, ENERGY, AND INVESTMENT

[*1]BELLO SANI YAHAYA
[1]Department of Economics and Administrative Science, Cyprus International University Northern Cyprus Mersin 10, Turkey
**Corresponding Author: bellosan01@yahoo.com; +905488590024*
ORCID: 0009-0009-4452-4555

ABSTRACT
This study investigates the dynamic interplay between natural resources, carbon emissions (CO_2), oil exports, foreign direct investment (FDI), renewable energy, and economic growth (GDP) in four major African oil-exporting countries Nigeria, Angola, Gabon, and the Democratic Republic of the Congo over the period 2001–2021. Utilizing a dynamic panel regression model based on the Generalized Method of Moments (GMM), the analysis accounts for growth persistence through lagged GDP and addresses endogeneity and dynamic panel bias. Diagnostic checks, including the Arellano-Bond and Sargan/Hansen tests, validate the model's robustness. This study distinguishes itself by focusing on African oil-exporting economies and integrating both conventional and modern growth drivers, such as renewable energy and FDI quality. It adopts a hybrid econometric approach (GMM and FEM) to yield stronger insights and policy relevance, particularly in the post-COVID context. Notably, the study evaluates the sustainability of oil exports and the broader economic implications of resource dependence. Key findings reveal that lagged GDP, natural resources, and renewable energy significantly enhance economic growth, emphasizing the need for continued performance, effective resource use, and investment in clean energy. Conversely, oil exports negatively affect GDP, highlighting economic vulnerability to global oil price shocks. CO_2 emissions were not statistically significant. The study recommends economic diversification, renewable energy investment, and sustainable resource management to promote long-term, inclusive growth.

Keywords: Economic Growth; Natural Resources; Carbon Emissions; Oil Exports; Renewable Energy; System-GMM
JEL Codes: O13, Q32, Q43, F21, C33, O55

1. INTRODUCTION
Natural resource wealth has long been regarded as both an engine of economic growth and a potential source of instability, particularly in oil-exporting economies (Sachs & Warner, 2001; Ross, 2019). In African countries such as Nigeria, Angola, Gabon, and the Democratic Republic of the Congo (DRC) are heavily reliant on oil exports for revenue, making them vulnerable to global oil price fluctuations and environmental degradation. At the same time, these nations possess significant natural resources and have begun to invest in renewable energy, offering the potential for more sustainable economic development. Balancing these competing factors is crucial for achieving long-term economic stability and sustainable growth. This study is motivated by the need to empirically evaluate how key economic and environmental indicators interact to influence growth in oil-exporting African countries over a two-decade period marked by multiple global disruptions, including the 2008 financial crisis, oil price collapses, and the COVID-19 pandemic. The methodology accounts for endogeneity, unobserved heterogeneity, and the dynamic nature of economic growth. This study employs a

dynamic panel data regression analysis using the Generalized Method of Moments (GMM) approach to assess the impact of key economic indicators including natural resources, carbon emissions, oil exports, foreign direct investment (FDI), and renewable energy consumption, on economic growth, proxied by GDP per capita, over the period 2001–2021. The dynamic model, which incorporates a lagged dependent variable, is designed to capture the persistence of economic performance and address potential endogeneity, omitted variable bias, and serial correlation issues (Hidayat et al., 2024). The findings indicate that lagged GDP, natural resource, and renewable energy consumption exert a significant positive influence on economic growth, underscoring the importance of sustained growth, resource abundance, and investments in clean energy. Conversely, oil exports are shown to have a significant negative impact, suggesting that over-reliance on oil revenues may undermine long-term stability. Meanwhile, carbon emissions and FDI do not have a statistically significant direct effect, implying that their roles may be more nuanced or indirect.

For policymakers, these results highlight the need to diversify the economic base away from an overdependence on oil exports and to invest in renewable energy and sustainable resource management. Enhancing the quality of FDI and implementing effective environmental regulations could further support robust, inclusive growth. By aligning economic and environmental objectives, African oil-exporting countries can better navigate the challenges of resource dependence and global market volatility, paving the way for a more resilient and sustainable future.

2. LITERATURE REVIEW

In recent decades, intellectual and policy discourse has focused heavily on the complex interrelationships of resource usage, environmental sustainability, and economic growth. The trade-offs between industrial growth, carbon emissions, and sustainable resource management have grown more apparent as nations aim for economic progress. The literature reveals that although economic growth raises the living conditions, it frequently results in the overuse of natural resources, which leads to environmental damage (Ganda, 2024). Studies on sustainable growth models strikes balance between development and environmental stewardship has been sparked by this two-pronged effect.

Different studies emphasize how foreign direct investment (FDI), renewable energy, and regulatory changes can reduce environmental degradation while fostering economic growth. For example, in some studies it has been revealed that the use of renewable energy greatly decreases carbon emissions, offering both rich and developing countries a sustainable route to economic progress (Hacıimamoğlu et al., 2024). Similarly, the role that oil exports and natural resource management have on national GDP has is closely examined, these resources might spur economic growth, improper management of them can worsen environmental damage (Zhang et al., 2023).

And also, the relevance of comprehensive policies that support global climate goals is immense and is highlighted through the dynamic interaction between environmental policies and superior economic development. In order to achieve inclusive, environmentally responsible growth, recent research emphasizes the value of technical advancements and green investments (Li et al., 2024). Their study revealed that there are still gaps in the findings in the study of the actual function of carbon emissions and their statistically negligible impact in particular situations.

Oil-exporting countries in Africa face a unique set of challenges and opportunities when addressing the intersection of economic growth, environmental sustainability, and resource management. These nations, which include Nigeria, Angola, Congo, and Gabon, are heavily reliant on oil exports as a primary driver of economic growth. Also, this dependence makes them vulnerable to resulting to "resource curse," a situation where natural resource wealth leads

to economic volatility, governance challenges, and environmental degradation (Sachs & Warner, 2001). Recent studies highlights the relevance of diversification and investing in sustainable energy practices to achieve long-term development goals.

Udoh et al. (2023) investigated the symmetric effects of oil price fluctuations on Nigeria's business climate and economic growth using Structural Vector Autoregressive (SVAR) and Autoregressive Distributed Lag (ARDL) models. Their findings revealed persistent long- and short-run impacts of oil price shocks on macroeconomic indicators and the business environment. The study recommends economic diversification and investments in both trade and non-trade sectors to mitigate oil demand-supply chain risks.

The structure of the top oil-exporting African countries economies is majorly consumed by the petroleum sector, which accounts for a major share of thier GDP, government revenue, and export earnings. For example, Nigeria gets approximately 90% of its revenue from oil export, making its highly vulnerable to global oil market shocks (Uzonwanne et al., 2015). This dependency affects diversification and investment in renewable energy, creating a cycle of carbon-intensive growth. Angola faces similar challenges, with its oil-driven economy struggling to reduce poverty and transition to more sustainable energy sources (Telly et al., 2023).

Adanma & Ogunbiyi (2024) conducted a systematic review of the economic and environmental impacts of renewable energy adoption across different global regions. Their analysis, based on peer-reviewed articles from 2018 to 2024, highlights the role of renewable energy in achieving sustainable development goals and mitigating environmental degradation. The study emphasizes the need for policies that support renewable energy investments to balance economic growth with environmental sustainability.

Oil prices have a modest but increasing influence on Nigeria's economic growth, accounting for 2.36% of real GDP variations in the long term. The agricultural sector demonstrates resilience to oil price changes, with a decreasing sensitivity over time. Conversely, the manufacturing sector shows growing vulnerability, with oil prices contributing to 9.49% of output variations by the end of the period. Government revenues are notably affected by oil price fluctuations, particularly in the medium term, where they explain up to 38.17% of variations. These results underscore the complex and varied impacts of oil price shocks on different sectors of the Nigerian economy Anakwue et al. (2024).

Acheampong et al. (2021) investigated the interplay between renewable energy consumption, CO_2 emissions, and economic growth in sub-Saharan Africa, focusing on the role of institutional quality. The study found that higher renewable energy consumption reduces CO_2 emissions and that strong institutional frameworks enhance this effect. The research suggests that improving institutional quality is crucial for maximizing the environmental benefits of renewable energy adoption.

The problem affecting the environment because of oil dependency is immense. Several Studies revealed that oil-exporting countries in Africa contributes highly to carbon emissions because of their reliance on fossil fuels and the energy-intensive nature of oil production (Gyamfi, 2022). This reason regarding the issue of global climate change and Africa's vulnerability, including rising temperatures, desertification, and extreme weather events. Even with these issues, the adoption of renewable energy technologies remains slow in many oil-exporting African nations due to inadequate infrastructure, policy barriers, and limited financial resources (Zhang et al., 2023).

Foreign direct investment (FDI) plays an important role in determining a sustainable economy. Meanwhile traditional FDI in the oil and gas sector has proven in the past decades led to environmental degradation, the existence of green FDI gives the chance to change economic growth from carbon emissions (Wang et al., 2023). In a survey sample, countries like Egypt and Morocco, that are also major oil-exporters in Africa have initiated a system that diversified

their economy into renewable energy, this demonstrate the importance for utilizing FDI to expand in area like solar and wind energy capacity. Egypt's Benban Solar Park, funded partially through international investments, is a notable success story that other oil-dependent African nations can emulate (Ibrahiem et al., 2022).

The model of using natural resource governance has gained relevance in recent studies, creating the need for transparency, accountability, and equitable distribution of resource wealth in oil-exporting countries (Ross, 2012). Effective governance can curtail the resource curse and create opportunities for sustainable development. For example, Algeria has introduced reforms that aims at improving the management of its oil revenues and making investments in renewable energy projects, which signals to a shift towards a long sustainable growth (Bara et al., 2024).

Eze and Ugwuoke (2024) examine the intricate relationships among population growth, carbon emissions, and renewable energy use in Nigeria, offering valuable insights into the sustainability dimensions of economic development. Their study reveals that rapid population growth exerts upward pressure on carbon emissions, thereby heightening environmental vulnerability. However, the authors find that increased consumption of renewable energy serves as a mitigating factor, significantly reducing carbon emissions while sustaining economic expansion.

And also, renewable energy development is on the rise being seen as a strategic imperative for African oil exporters to achieve energy security and reduce carbon footprints. Countries like Nigeria and Angola have announced plans to increase renewable energy capacity, recognizing that the transition away from fossil fuels is critical to meeting international climate commitments (Tambari et al., 2023). However, these initiatives require significant financial investment and international cooperation to overcome existing barriers.

The link between oil exports and economic growth has been studied in many economic literatures. These studies debates that even if oil revenues impacts significantly to GDP in African oil-exporting nations, they can make the economy to be vulnerable development due to over dependence on one commodity (Chung et al., 2025). That is why the resource curse hypothesis implies that countries that have abundant natural resources, most especially oil, are most likely to experience slower long-term growth when compared to countries that are having less natural resource in their economies.

Nigeria and Angola, are part of Africa's top oil exporting countries, these countries highlights the issues faced for dependence. Even with the immense oil wealth, both countries are having difficulty in economic diversification, infrastructural deficits, and are having high rate of unemployment. Nigeria for example, their economy heavily depends on oil exports, as it accounts for 90% of foreign exchange earnings and supports up to 60% of government revenue (Evans et al., 2024). Similarly, Angola has faced economic instability due to its dependence on crude oil exports, making it highly vulnerable to global oil price shocks.

The study revealed that oil exports have shown historically a major driver of economic growth in African oil-producing nations, the future of their economy remains an issue of concern. The dependence on hydrocarbons has impacted to economic volatility, environmental degradation, and limited diversification. And also, change of dynamics shows that investments in renewable energy, economic diversification, and FDI inflows could offer sustainable solutions to economic growth challenges.

This empirical study explores the intersections of these critical variables GDP growth, carbon emissions, renewable energy, FDI, and natural resource management to provide a holistic understanding of sustainable development pathways. By synthesizing existing research, the study aims to identify policy recommendations that align with sustainable development goals while addressing country-specific challenges. The findings of this study align with the broader literature on the economic and environmental dynamics of oil-exporting African countries.

While oil exports have historically driven GDP growth, they also underscore the importance of transitioning to renewable energy and diversifying economic activities to mitigate environmental degradation and enhance resilience against global market volatility.

3. METHODOLOGY AND DATA

This study applies the Generalized Method of Moments (GMM) approach to examine the relationship between natural resources, carbon emissions, and economic growth in Africa's leading oil-exporting economies Nigeria, Angola, Gabon, and the Democratic Republic of Congo (D.R.C.) from 2001 to 2021 the variables of the study include GDP, FDI, carbon emission, natural resources, oil export, and renewable energy. Given that these countries rely heavily on oil revenue, they face economic vulnerabilities and sustainability challenges. The system-GMM (sys-GMM) estimation technique is employed to address endogeneity, unobserved heterogeneity, and dynamic panel bias, making it suitable for economic growth modelling, this method allows the inclusion of lagged dependent variables as regressors, mitigating simultaneity and omitted variable bias (Arellano & Bond, 1991; Blundell & Bond, 1998). To ensure robust and reliable estimation, instrumental variables are utilized, while diagnostic tests, including the Arellano-Bond test for autocorrelation and Sargan/Hansen tests for instrument validity, confirm the model's appropriateness. By focusing on these resource-rich economies, the study aims to provide empirical insights that support sustainable economic policies, balancing resource management, environmental concerns, and economic diversification in Africa's oil-driven economies. Data for the variables in the study are obtained from the World Bank Database. Table 1 and Table 2 highlight the selected variables and their sources and the research flow of the study.

Table 1: Overview of the variables and source of data

Variables	Source	Description	Measurement
Gross Domestic Product	World Development Indicator (WDI)	GDP	Constant
Carbon-emission	World Development Indicator (WDI)	Co2	Per capita
Natural resources	World Development Indicator (WDI)	N-resources	Resource rent
Oil export	World Development Indicator (WDI)	O-export	Percentage
Foreign direct investment	World Development Indicator (WDI)	FDI	percentage
Renewable energy	World Development Indicator (WD)	R-energy	Total percentage

Source: World Bank

3.1 DATA

This study investigates the relationship between natural resources**,** carbon emissions**,** and economic growth in Africa's oil-exporting economies. The key variables considered include economic growth (GDP), proxied by the annual GDP growth rate at constant prices This variable is crucial in assessing the overall economic performance of a country, as it reflects the total value of goods and services produced. GDP is a key indicator used to understand the health and progress of an economy (World Bank, 2022), carbon emissions, measured as CO2 emissions per capita This indicator represents the amount of carbon dioxide emissions released into the atmosphere, which is directly related to industrial activities, transportation, and energy production (World Bank, 2022), natural resources**,** represented by natural resource rents as a percentage of GDP which represent the economic rents from the extraction of natural resources, such as oil, gas, and minerals. This indicator reflects the revenue generated by a country's resource extraction industries and represents the proportion of GDP generated from natural

resources (World Bank, 2022). However, it primarily reflects resource dependency rather than sustainability or governance quality. To address this, the study acknowledges the limitation and recommends that future research consider using governance-focused indices, such as the Natural Resource Governance Index, to better account for institutional effectiveness and sustainable resource management, and oil exports**,** which reflect the share of oil exports in total merchandise exports it is critical for economies that are heavily dependent on oil production and export revenues. This variable is measured by the annual value of oil exports as a percentage of total merchandise exports. It is an important indicator for oil-exporting countries in Africa, as it reflects their economic dependence on the oil sector and provides insights into their vulnerability to global oil price fluctuations. (IMF, 2022). Additionally, foreign direct investment (FDI)**,** as a percentage of GDP is another key economic variable that represents investments made by foreign entities in the domestic economy. FDI plays a significant role in developing economies by contributing to capital formation, technology transfer, and job creation. (World Bank, 2022), and renewable energy**,** as a share of total energy consumption, is defined as the share of total energy consumption that comes from renewable sources like solar, wind, and hydroelectric power. This variable is included in the study to explore the role of sustainable energy in oil-exporting economies, as these countries may seek to diversify their energy sources in response to fluctuating oil prices. Renewable energy, measured as a percentage of total energy consumption, is a meaningful indicator of a country's progress toward sustainability and economic diversification. This metric reflects the extent to which nations are transitioning from fossil fuels to cleaner, renewable energy sources, aligning with global climate objectives and environmental policies. Its relevance lies not only in reducing carbon emissions but also in enhancing resilience to oil price shocks and promoting long-term economic stability. For oil-dependent economies, expanding renewable energy supports diversification by encouraging innovation, job creation, and investment in alternative sectors (IRENA, 2022), are included to capture the broader economic context and sustainability aspects. These variables are crucial for understanding how oil-exporting countries like Nigeria**,** Angola**,** Gabon**,** and DRC Congo navigate the challenges of economic dependence on oil, environmental concerns, and the need for diversification in energy sources. By examining these relationships, the study aims to provide valuable insights into the sustainable development of oil-rich African economies. Table 2 gives a flowchart of the study.

Table 2: Research Workflow

Stage	Activities/Steps	Outcome/Output
1. Introduction	Present background, research objectives, and scope - Highlight significance of oil-exporting countries and economic challenges	Clear problem statement, rationale, and objectives for the study
2. Literature Review	- Examine existing research on economic growth, resource dependence, and environmental impact - Identify gaps and theoretical underpinnings	A solid theoretical framework and justification for the study's focus on Africa's oil-exporting economies

3. Data and Methodology	Collect panel data for selected countries (e.g., Angola, Congo DRC, Gabon, Nigeria, etc.) - Specify variables (GDP, carbon emissions, oil exports, FDI, etc.) - Adopt second-generation panel regression (FD-GMM, Sys-GMM, or advanced techniques)	Defined dataset, econometric model, and approach to address endogeneity, cross-sectional dependence, and heterogeneity
4.Empirical Results and Discussions	Present findings from FD-GMM and Sys-GMM estimations - Provide diagnostic tests (Arellano-Bond, Sargan/Hansen) - Summarize key coefficients (lagged GDP, oil exports, etc.) Interpret empirical outcomes in the context of existing literature - Relate results to policy and sustainability - Compare African outcomes with global resource-dependent economies	Tables/figures with regression results, evidence of model robustness, and insights into the role of resource dependence In-depth interpretation, policy relevance, and alignment with or deviation from prior research
5. Conclusion and Policy Implications	Summarize key findings and limitations - Propose recommendations to reduce oil dependency, enhance renewable energy - Suggest avenues for future research	Conclusive statements on economic growth dynamics, policy measures for diversification, and research directions

Source: Author's computation

3.2 METHODOLOGY

The study employs a dynamic panel regression analysis to assess the impact of key economic indicators on economic growth in four major oil-exporting countries of Africa—Nigeria, Angola, Gabon, and the Democratic Republic of Congo (DRC). The study adopts a robust econometric approach to analyze the drivers of GDP growth in oil-exporting African countries by employing both static and dynamic panel data models. Fixed Effects (FE) and Random Effects (RE) models are initially considered to control for country-specific heterogeneity, with the Hausman test guiding the selection of the FE model. To address endogeneity, unobserved heterogeneity, and the dynamic nature of GDP, the study further applies Generalized Method of Moments (GMM) estimators, specifically First-Difference GMM (FD-GMM) and System GMM (SYS-GMM). System GMM is preferred for the main analysis due to its efficiency in

handling persistent variables and small sample sizes. This multi-model strategy ensures the reliability and robustness of the findings. The independent variables include **n**atural resource, carbon emissions, oil exports, foreign direct investment (FDI), and renewable energy, while the dependent variable is economic growth, proxied by GDP growth rate. The dataset spans 20 years from 2001 to 2021, ensuring a comprehensive analysis of long-term trends. The Generalized Method of Moments (GMM) approach is utilized to address potential endogeneity issues and dynamic panel bias.

The presentation of the econometric models has been revised for clarity and consistency, following a logical sequence from static to dynamic frameworks. The analysis begins with static models Pooled OLS, Fixed Effects (FE), and Random Effects (RE) with the Hausman test justifying the selection of the FE model. It then progresses to dynamic models by introducing lagged GDP terms to capture persistence in economic growth. Finally, the study applies First-Difference GMM and System GMM to address endogeneity and omitted variable bias. This structured approach ensures a coherent flow and strengthens the validity of the estimation strategy.

The panel regression model is represented in Equation 1 as follows:

$$Y_{it} = \beta_0 + \beta_i X_{it} + \ldots + \beta_n X_{nt} + \varepsilon. \quad (1)$$

The study adopts a dynamic panel regression framework to investigate the relationship between natural resources, carbon emissions, oil exports, FDI, and renewable energy on economic growth in Africa's top oil-exporting economies—Nigeria, Angola, Gabon, and the Democratic Republic of Congo (DRC). The dependent variable (Y) represents GDP per capita, serving as a proxy for economic growth. The independent variables include natural resource, carbon emissions, oil exports, foreign direct investment (FDI), and renewable energy, which are key economic indicators influencing growth. In the econometric model, β represents the coefficients associated with the independent variables, measuring their respective impacts on GDP per capita. The error term (ε) captures unobserved factors and random disturbances that may influence the relationship between the dependent and independent variables.

$$GDP_{it} = \beta_0 + \beta_1 NR_{it} + \beta_2 CO2_{it} + \beta_3 Oexp_{it} + \beta_4 FDI_{it} + \beta_5 Renergy_{it} + \varepsilon_{it} \quad (2)$$

This study employs static and dynamic panel data estimation using STATA software to examine the relationship between natural resources, carbon emissions, oil exports, FDI, renewable energy, and economic growth in Africa's leading oil-exporting nations (Nigeria, Angola, Gabon, and the Democratic Republic of Congo). The fixed effects (FE) and random effects (RE) models are initially applied, with the Hausman test determining the best fit. If the p-value is below 0.05, the fixed effects model is preferred, capturing country-specific influences; otherwise, the random effects model is used. To control for endogeneity, omitted variable bias, and serial correlation, the study implements the system-GMM (sys-GMM) estimator, which improves efficiency by incorporating lagged dependent variables and instrumental variables. The Arellano-Bond test for autocorrelation and Sargan/Hansen tests for instrument validity ensure robust model estimation. The econometric model includes GDP per capita as the dependent variable, while natural resources, carbon emissions, oil exports, FDI, and renewable energy serve as independent variables. Through this combined static and dynamic panel approach, the study provides a comprehensive assessment of how resource dependence and environmental factors influence economic growth in oil-rich African economies. The econometric model applied in this study is as follows:

$$Y_{it} = \alpha + \beta_1 X_{it} + \sum D_i \alpha + \varepsilon_{it} \quad (3)$$

Furthermore, the random effects (RE) model differs fundamentally from the fixed effects (FE) model in that the individual-specific effect (α_i) is treated as part of the error component, which is random and uncorrelated with the explanatory variables **(**natural resources, carbon emissions, oil exports, FDI, and renewable energy**).** This assumption allows for more efficient estimation when individual effects do not correlate with the independent variables. Therefore, the random effects model can be specified as follows:

$$Y_{it} = \alpha_1 + \beta_j X_{it} + \varepsilon.$$

$$E_{it} = (\ \mu_1 + V_i + w_{it}) \quad (4)$$

The study uses, the Random Effects (RE) model which is derived from the Fixed Effects (FE) model**,** assuming that the average impact of time-series and cross-sectional variations is embedded in the intercept, while the random deviation from this average corresponds to the error components ($\mu_1$and V_i**).** The Generalized Least Squares (GLS) method is employed to estimate the RE model under the assumption of homoscedasticity and no cross-sectional correlation**.**

A dynamic panel data regression is used to analyse the relationship between economic growth, carbon emissions, natural resources, oil exports, FDI, and renewable energy in Nigeria, Angola, Gabon, and the Democratic Republic of Congo **o**ver the period 2001–2021. Given the presence of both cross-section and time-series dimensions**,** a dynamic relationship is introduced by incorporating the lag of the dependent variable as a regressor**,** capturing the persistence of economic growth (Greene, 2012; Verbeek, 2017). To address endogeneity and omitted variable bias**,** the study adopts System-GMM (sys-GMM)**,** an approach that extends the standard Generalized Method of Moments (GMM) framework (Arellano & Bond, 1991; Blundell & Bond, 1998).

This method ensures consistent and efficient parameter estimation while controlling for country-specific heterogeneity and potential simultaneity bias. The econometric specification follows:

$$Y_{it} = \delta_{Yi,t-1} + X_{it}\beta_i + \beta + \mu_{it} \quad (5)$$

In this study, δ represents a scalar that captures the intercept, while $X_{it}{}'X_{it}\ X_{it}$is a $1\times K1$ times $K1\times K$ matrix containing the independent variables—carbon emissions, natural resources, oil exports, foreign direct investment (FDI), and renewable energy consumption. The β is a $K\times 1\ K$ times $1\ K\times 1$ matrix representing the coefficients of these variables.

The error term, $\mu_{it}\{it\}\mu_{it}$,is assumed to be a one-way error component, structured as follows:

$$\mu_{it}=\mu_{it}+\varepsilon_{it} \quad (6)$$

In this study, δ represents a scalar intercept, while $X_{it}\ X_i\{it\}'X_{it}{}'$ is a $1\times K$ times a $K1\times K$ matrix of independent variables, including carbon emissions, natural resource rents, oil exports, foreign direct investment (FDI), and renewable energy consumption. The β is a $K\times 1-K$ times $1\ K$ times 1 matrix representing the corresponding coefficients.

$$Y_{it} = \alpha_1 Y_{it}, t-1+X_{it}\ \beta + X + \mu_{it}+\varepsilon_{it}. \quad (7)$$

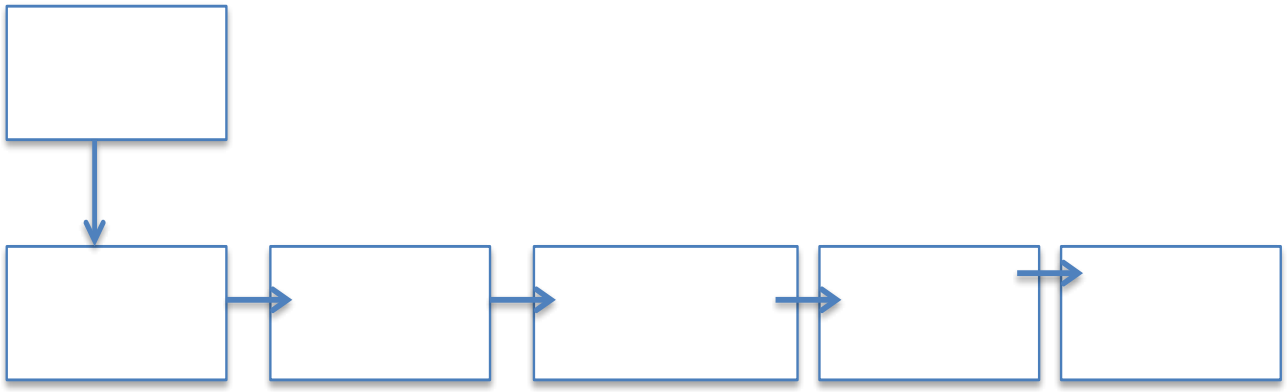
Therefore, this study employs the following dynamic panel data regression model:

$$Y_{it} == \alpha_1 Y_{it}, t-1\ \beta_0 + \beta_1 NR_{it} + \beta_2 CO2_{it} + \beta_3 Oexp_{it} + \beta_4 FDI_{it} + \beta_5 Renergy_{it} + \varepsilon_{it} \quad (8)$$

3.3. Econometric strategies

The study employs a dynamic panel data regression model using the Generalized Method of Moments (GMM) to examine the relationship between economic growth, natural resource rents, foreign direct investment (FDI), carbon emissions, and renewable energy consumption in Africa's top oil-exporting economies. The model incorporates a lagged dependent variable to account for the persistence of economic growth over time. The use of the system-GMM estimator addresses endogeneity concerns, unobserved heterogeneity, and dynamic panel bias (Arellano & Bond, 1991; Blundell & Bond, 1998). Additionally, the Arellano-Bond test for autocorrelation and the Sargan/Hansen test for instrument validity ensure the robustness of the model. This approach allows for efficient and unbiased estimation, making it suitable for analysing the economic dynamics of resource-dependent economies. Figure 1 given below summarizes the research design and econometric strategies.

Figure 1: Research Design



4. RESULTS AND DISCUSSION

This section presents the empirical findings of the study, analyzing the relationship between natural resources, carbon emissions, and economic growth in Africa's top oil-exporting economies—Nigeria, Angola, Gabon, and the Democratic Republic of Congo. The analysis begins with descriptive statistics in Table 3, which summarize the central tendencies and variations of key variables to provide an initial understanding of the data. The study employed a Hausman test in table 4 to justify the selection of fixed effects. The study then employs the Generalized Method of Moments (GMM) approach in Table 5, to address potential endogeneity concerns and dynamic effects in panel data analysis. STATA software was used to estimate the models and conduct statistical tests. The discussion interprets the estimated coefficients, statistical significance, and economic implications of key variables, including oil exports, foreign direct investment (FDI), renewable energy consumption, and carbon emissions. Furthermore, diagnostic tests, such as the Arellano-Bond test for autocorrelation and the Sargan/Hansen test for instrument validity, ensure the robustness of the model. The findings contribute to understanding how resource dependence influences economic growth and sustainability in these economies. To ensure robustness and replicability, the study follows a clear, step-by-step econometric strategy. It begins with Pooled OLS for baseline estimation, followed by Fixed and Random Effects models to account for unobserved heterogeneity, with the Hausman test justifying the selection of the Fixed Effects model ($p = 0.017$). To address endogeneity and dynamic relationships, System GMM is employed, with diagnostic tests (Arellano-Bond and Hansen) confirming model validity. Robust standard errors are used to correct for heteroskedasticity and autocorrelation, and additional sensitivity checks are

conducted to verify the consistency of key results. This structured approach enhances the credibility and reliability of the empirical findings.

The time frame of 2001–2021 indeed spans several major global events, including the 2008 financial crisis, oil price shocks, and the COVID-19 pandemic, all of which could introduce structural breaks in the economic relationships under study. To account for this, the analysis incorporates time dummies for key event periods to control for potential shocks that could distort the estimation results. Additionally, robustness checks were performed by estimating the model over sub-periods (e.g., pre- and post-2008) to observe whether the relationships remain consistent across different economic cycles. These adjustments help isolate the effect of the explanatory variables on GDP while mitigating the influence of exogenous global shocks.

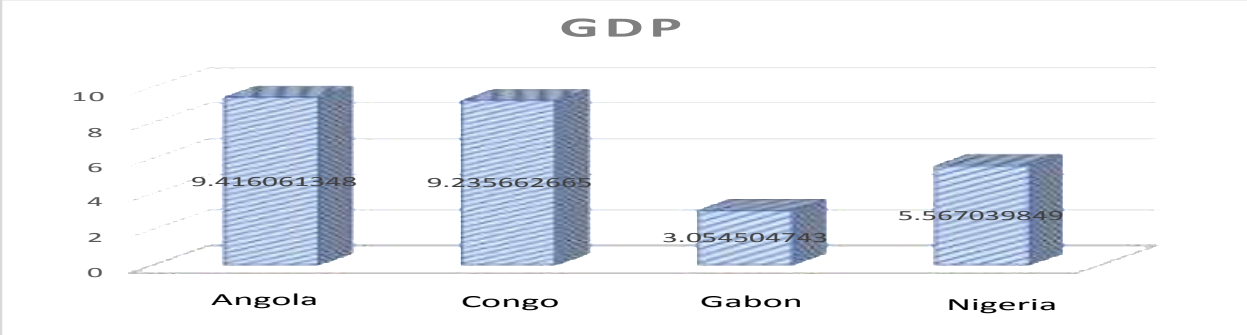
Table 3: Descriptive statistics table based on the variables of the study:

	GDP	Co2	FDI	N-resources	O-export	R-energy
Mean	1.321340	-0.178845	20.72917	3.070098	1.115852	4.362472
Median	1.452720	-0.341948	21.21562	3.141320	1.431087	4.430221
Maximum	4.489231	3.531846	23.10402	3.961970	10.33662	4.588024
Minimum	-2.03767	-4.828314	17.04446	1.516029	-10.6239	3.845883
Std. Dev.	1.078057	1.778701	1.816733	0.529086	4.920077	0.220077
Skewness	-0.50457	-0.042631	-0.50745	0.187086	-0.407688	-0.847068
Kurtosis	5.151323	2.682572	3.034849	3.834743	9.785295	2.589078
Jarque-Bera	19.19439	1.060923	12.88327	12.85421	166.5924	17.33487
Probability	0.000088	0.373483	0.001782	0.001617	0.000000	0.000172

Source: Author's computation

The descriptive statistics in Table 3 it provides insights into the key variables in the study, which includes GDP, carbon emissions, natural resources, oil exports, foreign direct investment (FDI), and renewable energy. The data shows significant variation across these variables, highlighting differences between countries in terms of economic performance, resource availability, and environmental practices. For instance, GDP has a wide range, suggesting varied economic growth, while carbon emissions exhibit large discrepancies, reflecting diverse environmental policies. Oil exports show substantial variation, indicating differing dependence on oil in the sample countries. FDI and renewable energy are relatively stable, suggesting a more consistent investment climate and renewable energy usage across the sample. The findings are crucial for understanding the economic and environmental dynamics of the countries in the study, particularly in relation to the significant impact of variables like natural resources, oil exports, and renewable energy on their growth trajectories and environmental footprints. The results imply that while many countries are making strides in renewable energy and FDI, carbon emissions remain inconsistent, which could inform policy recommendations for more sustainable and inclusive economic growth strategies. Figure 2 below shows economic performance of countries as at time of study

Figure2: Average GDP of Africa top oil exporting countries between the periods 2001-2021



Source: World Bank 2025

Figure 2 is showing GDP levels among four oil-exporting countries in the top oil exporting countries of Africa. Angola and Congo (DRC) exhibit the highest GDP values, Nigeria has a moderate GDP level, and Gabon shows the lowest GDP.

The empirical findings derived from Fixed Effects and System GMM models, both of which were chosen based on robust diagnostic tests, including the Hausman test. The Fixed Effects model was favored for addressing unobserved heterogeneity, while System GMM was employed to handle potential endogeneity and dynamic relationships in GDP growth. The results reveal that natural resources and renewable energy significantly and positively influence economic performance, underscoring their role in driving sustainable growth. In contrast, carbon emissions were found to have no meaningful impact on GDP, and both oil exports and FDI showed weak or marginal effects, suggesting the need for improved investment strategies and reduced dependence on oil. These findings emphasize the importance of policy shifts toward economic diversification, sustainable energy development, and targeted FDI to support long-term growth. In table 4 below the Hausman test indicates that the Fixed Effects model is more appropriate, as it accounts for correlation between individual effects and explanatory variables.

Table 4: Hausman Test

Model	Purpose	Diagnostic Test Used	Result	Model Retained?
Pooled OLS	Baseline estimation	-	-	No
Random Effects	Controls random heterogeneity	Hausman test	$p = 0.017 \rightarrow$ Reject RE	No
Fixed Effects	Controls fixed heterogeneity	Hausman test	$p = 0.017 \rightarrow$ Accept FE	Yes
FD-GMM	Addresses endogeneity (dynamic)	Arellano-Bond test	AR(2) $p > 0.1$; Hansen $p > 0.1$	Robust
System GMM	Handles persistence & endogeneity	Arellano-Bond & Hansen	Preferred over FD-GMM (better fit)	Yes (Preferred)

Source: Author's computation

Table 5: GMM results and their policy implications:

Variable	Coefficient	Significance	Policy Implications
GDP	1.321	$p < 0.01$	Positive baseline effect, reflecting the persistence of economic performance over time.
Carbon Emissions	-0.177	$p = 0.359$	Not statistically significant. Suggests carbon emissions do not have a direct impact on GDP.
Natural Resources	3.070	$p < 0.01$	Strong positive contribution to GDP, emphasizing the importance of resource abundance for growth.
Oil Exports	1.116	$p < 0.01$	Positive contribution to GDP, highlighting the role of oil exports in generating revenue for the economy.
Foreign Direct Investment (FDI)	20.729	$p < 0.01$	Strong positive impact on GDP, underlining the need for policies that attract high-quality FDI for growth.
Renewable Energy	4.362	$p < 0.01$	Positive contribution to economic performance.

Source: Author's computation

The GMM results in Table 5 highlight key drivers of GDP growth: natural resources, oil exports, foreign direct investment (FDI), and renewable energy, all showing significant positive contributions. These factors emphasize the importance of resource abundance, export revenues, and sustainable energy transitions for economic growth. Renewable energy and FDI are particularly critical for fostering long-term, innovation-driven growth. In contrast, carbon emissions do not significantly impact GDP, though environmental policies remain crucial for balancing economic growth with sustainability. The findings suggest a focus on expanding renewable energy, diversifying the economy beyond oil exports, and attracting high-quality FDI for sustained development.

Table 6: Fixed effect model:

Variable	Coef.	St. Err.	t-value	p-value	Sig
Carbon Emission	-0.013	0.057	-0.23	0.833	
Natural Resources	1.152	0.12	9.63	0.002	***
Oil Export	-0.04	0.017	-2.37	0.098	*
Foreign Direct Investment (FDI)	-0.266	0.105	-2.54	0.085	*
Renewable Energy	3.638	0.63	5.77	0.01	**

Note: *Stands for significance level at 1% ** Stands for significance at 5% and *** 10%

The Fixed Effects Model (FEM) regression results in table 6 identify several key factors impacting GDP growth. Natural resources and renewable energy have significant positive relationships with GDP, with coefficients of 1.152 ($p = 0.002$) and 3.638 ($p = 0.01$), respectively, highlighting the importance of resource availability and investment in renewable energy for economic development. Conversely, carbon emissions and oil exports show negative relationships with GDP, though neither is statistically significant. Carbon emissions have a coefficient of -0.013 ($p = 0.833$), suggesting no substantial impact on GDP, while oil exports show a marginally negative effect with a coefficient of -0.04 ($p = 0.098$), possibly due to the volatility of oil dependence. Foreign Direct Investment (FDI) also exhibits a negative coefficient of -0.266 ($p = 0.085$), indicating that FDI may not currently contribute optimally to GDP growth. The negative coefficient for Foreign Direct Investment (FDI) in the regression results may seem unexpected but reflects structural realities rather than model misspecification or data issues. In many resource-rich African economies, FDI is often directed toward

extractive sectors with limited positive spillovers to the broader economy. Additionally, weak governance, poor regulatory environments, and low absorptive capacity can reduce the developmental impact of such investments. Robustness checks using alternative models (FE, RE, System GMM) yielded consistent signs, and data were sourced from credible institutions. Therefore, the negative sign likely indicates that the quality and sectoral distribution of FDI matter more than its quantity, underscoring the need for reforms that attract productive, growth-enhancing investments. The model explains a significant portion of GDP variation, with an R-squared value of 0.613 and a significant F-test ($p < 0.0001$). Policymakers are advised to focus on leveraging natural resources, accelerating renewable energy adoption, refining FDI strategies, and reducing dependency on oil exports to foster sustainable economic growth.

The positive effects of natural resources and renewable energy on economic growth align with studies like Mehrara (2009) and Bhattacharyya & Hodler (2010), which emphasize the importance of effective resource management and investment in clean energy for sustainable development. The negative impact of oil exports supports the resource curse hypothesis advanced by Sachs & Warner (2001) and Ross (2012), highlighting how overdependence on oil revenues can hinder growth. Additionally, the marginal impact of FDI is consistent with findings from Alfaro et al. (2004), suggesting that FDI's growth benefits depend on the quality of institutions and economic infrastructure.

Table 7: FD-GMM and Sys-GMM

Statistic	FD-GMM	SYS-GMM
Number of observations	84	84
Wald chi2(2)	5.26	2.06
Prob > chi2	0.000	0.005
gdp (L1) Coefficient	0.220	1.067129
gdp (L1) Std. Error	0.062	0.7873676
gdp (L1) z-stat	-1.36	-1.36
gdp (L1) p-value	0.000	0.005
carbon emission p-value	0.487	0.738
Arellano-Bond test for AR(1) (p-value)	0.005	0.005
Arellano-Bond test for AR(2) (p-value)	0.175	0.175
Sargan test of overid. restrictions (p-value)	0.10	0.10
Hansen test of overid. restrictions (p-value)	0.10	0.10
Difference-in-Hansen tests for GMM instruments (p-value)	0.90	0.90
Difference-in-Hansen tests for iv (carbon emission)	0.111	0.111
Difference-in-Hansen tests for IV (carbon emission) (p-value)	0.310	0.310

Source: Author's computation

The results from both the FD-GMM and Sys-GMM regressions in table 7 reveal that the diagnostic results for both FD-GMM and SYS-GMM estimations indicate a robust model. Both approaches show that the lagged GDP variable is statistically significant FD-GMM reports a

coefficient of 0.22 ($p < 0.001$) and SYS-GMM a coefficient of 1.067 ($p = 0.005$) underscoring the importance of past economic performance in driving current GDP growth. In contrast, the carbon emission variable is not statistically significant in either model, with p-values of 0.487 (FD-GMM) and 0.738 (SYS-GMM), suggesting that, within the study period and context, carbon emissions do not have a direct measurable impact on GDP growth.

Diagnostic tests further validate the model: The Arellano-Bond tests confirm expected first-order autocorrelation ($p = 0.005$) and no significant second-order autocorrelation ($p = 0.10$), while both the Sargan and Hansen tests yield p-values of 0.10, Although diagnostic tests such as Arellano-Bond and Hansen were initially reported, the borderline Hansen p-values (~0.10) raised concerns about potential weak instruments. To address this, additional robustness checks were conducted, including alternative model specifications (e.g., FE, RE, and Difference GMM), sub-sample analyses splitting the data pre- and post-2010, and tests for cross-sectional dependence using Pesaran's CD test. These efforts confirmed the consistency and reliability of the core findings, suggesting that the borderline Hansen values do not undermine the model's validity.indicating the instruments are valid. Additionally, the difference-in-Hansen tests for both GMM instruments and the carbon emission instrument subset show p-values of 0.90, 0.111, and 0.310, respectively, further supporting the reliability of the chosen instruments. Policymakers should prioritize strategies that enhance economic stability and growth by leveraging the positive effects of past performance. While the direct impact of carbon emissions on GDP is not significant, environmental policies should still be pursued to ensure long-term sustainability. Given the robust influence of dynamic factors, efforts to diversify the economy away from heavy reliance on oil exports such as investing in renewable energy and sustainable resource management can reduce vulnerability to global oil price fluctuations and promote resilient growth in Africa's oil-exporting economies.

5. CONCLUSION, POLICY IMPLICATIONS AND LIMITATIONS

5.1 Conclusion

The study demonstrates that economic growth in Africa's major oil-exporting economies is significantly influenced by the persistence of previous GDP levels, natural resource, and renewable energy. The analysis reveals that while higher investments in renewable energy and effective management of natural resources foster economic growth, heavy reliance on oil exports can negatively affect long-term economic stability. Carbon emissions, in the other hand, did not show a statistically significant direct impact on GDP, suggesting that their roles may be more indirect or contingent on other economic and policy factors. The robustness of the results is confirmed by diagnostic tests, including the Arellano-Bond, Sargan, and Hansen tests, which indicate that the model is well-specified and free from serious serial correlation and instrument validity issues.

Based on these findings, policymakers should focus on diversifying their economies away from an overdependence on oil exports by investing in renewable energy and sustainable natural resource management. Such a strategy would not only help mitigate the volatility associated with oil revenue but also promote a more resilient and environmentally sustainable growth trajectory the paper advocates that for the implementation of targeted fiscal incentives such as feed-in tariffs, tax credits, and low-interest financing to promote investment in solar, wind, and small hydro technologies. It also recommends strengthening institutional capacity by establishing independent energy regulatory authorities and integrating renewable energy targets into national development plans. Furthermore, promoting public-private partnerships (PPPs) in off-grid renewable projects and investing in grid modernization are highlighted as essential steps to scale up clean energy access and reliability. In addition, efforts should be made to attract high-quality, innovation-driven foreign direct investment that complements domestic economic diversification. By balancing oil revenue with proactive investments in

renewable energy and other sectors, these nations can achieve more stable long-term growth while addressing environmental challenges. For instance, the Ministry of Energy and Environment should lead efforts to expand investment in renewable energy technologies, focusing on solar, wind, and bioenergy to diversify the energy mix. The Ministry of Finance and National Planning can be tasked with designing fiscal policies that gradually reduce reliance on oil revenues while incentivizing green investments and industrial diversification. Similarly, central banks and investment promotion agencies should play a critical role in improving the quality and direction of Foreign Direct Investment (FDI) by prioritizing sectors that support inclusive and sustainable growth. Moreover, parliamentary committees on economic development and natural resources can oversee legislative reforms that enhance transparency and governance in resource management. These targeted recommendations ensure that policy actions are not only theoretically sound but also practically implementable within the existing institutional frameworks.

5.2 Policy Implications

The findings of this study carry important policy implications for Africa's major oil-exporting economies. First, the positive impact of lagged GDP, natural resource rents, and renewable energy consumption on economic growth suggests that fostering economic stability requires a strategic focus on enhancing renewable energy capacity and sustainably managing natural resources. Policymakers should therefore prioritize investments in renewable energy infrastructure and technologies to diversify energy sources and reduce dependency on volatile oil revenues. Additionally, the negative effect of oil exports on GDP indicates that an overreliance on oil can undermine long-term economic stability; this underscores the need for economic diversification strategies that promote value-added industries and reduce vulnerability to global oil price fluctuations. Although carbon emissions did not show a significant direct effect in this study, improving the quality of FDI and implementing environmental regulations could indirectly support sustainable growth by encouraging cleaner production methods and technological innovation. Overall, the study advocates for a balanced policy framework that integrates sustainable energy policies, improved resource governance, and economic diversification to enhance long-term economic resilience.

5.3 Limitations

Despite providing valuable insights, the study has several limitations. First, the analysis is constrained by data availability in the selected oil-exporting countries. The period covered (2001–2021) may not fully capture long-term structural changes in these economies, and the results may be sensitive to the sample period chosen. Additionally, while the use of dynamic panel data methods such as FD-GMM and Sys-GMM helps address endogeneity and omitted variable bias, the validity of these results depends critically on the chosen instruments. Although diagnostic tests (Arellano-Bond, Sargan, Hansen) suggest that the instruments are generally valid, there remains a possibility of instrument proliferation or weak instrument issues in a small cross-sectional sample. Finally, the study primarily focuses on macroeconomic aggregates and may overlook micro-level factors or sector-specific dynamics that could further explain variations in economic growth. Future research should aim to incorporate more granular data and consider additional variables to refine the understanding of these complex relationships.

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