MODELLING IMPACT OF RENEWABLE ENERGY CONSUMPTION TRADE OPENNESS AND FOREIGN DIRECT INVESTMENT ON ECONOMIC GROWTH IN NIGERIA

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ABSTRACT

This aimed at modelling the impact of renewable energy consumption trade openness and foreign direct investment on economic growth in Nigeria. The study used secondary data which were collected from World Development Indicator (WDI) covering a period of thirty-four (34) years spanning from 1990 - 2023. The data collected were analyzed using Vector Error Correction Model (VECM). Unit root test was carried out using Augmented Dickey Fuller (ADF)Test and Phillips Perron (PP) test. The results of the root test revealed that Renewable Energy Consumption (REC), Trade Openness (TO), Foreign Direct Investment (FDI) and Gross Domestic Product Per Capita (GDPPC) were stationary after first difference ($P< 0.05$). The variables were further tested for existence of co-integration using Johansen and Joserius. The results revealed the existence of one co-integrating equation. Thus, the VECM long and short run were estimated. The results revealed an Error Correction Term (ECT) of -0.235917 implies that an impulse to gross domestic product per capita in the current period will be restored at a speed of adjustment of about 23.6% in the next period. The long run estimated revealed that FDI and TO have negative and significant impact on GDPPC while REC has positive and significant impact on GDPPC in the long run. However, only REC have significant impact on GDPPC in the short run. Based on these findings, it was recommended among others that the government and general public should priorities renewable energy consumption as it contributed positively to gross domestic product per capita both in short and long run.

Keywords: *Economic Growth, Renewable Energy Consumption, Trade openness, Foreign Direct Investment & vector Error Correction Model*.

1.0 Introduction

Nigeria, Africa's largest economy, has struggled with sustainable economic growth due to its dependence on non-renewable energy sources and vulnerability to global market fluctuations (Yang et al, 2022). Renewable energy consumption is essential for mitigating climate change and ensuring sustainable development. Trade openness and FDI also play significant roles in promoting economic growth (Gold & Tregenna, 2024; Eberechukwu et al, 2024). The relationship between renewable energy consumption and economic growth has been found to be bi-directional,

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with a significant positive impact of renewable energy consumption on economic growth in Nigeria (Umeji *et al*, 2023). Additionally, studies have shown that trade openness and FDI have positive and significant impacts on economic growth in Nigeria (Gold & Tregenna, 2024; Eberechukwu et al, 2024). However, the impact of renewable energy consumption, trade openness, and FDI on economic growth in Nigeria is complex and influenced by various factors. in addition, the nation faces significant challenges in harnessing renewable energy potential, leveraging trade openness, and attracting foreign direct investment to drive sustainable economic growth. The Vector Error Correction Model (VECM) is a statistical model that examines the relationships between multiple time series variables. It is an extension of the Vector Autoregression (VAR) model, which allows for the incorporation of cointegration relationships between the variables (Johansen, 1988; Engle & Granger, 1987). In this study, the VECM is used to model the impact of renewable energy consumption, trade openness, and foreign direct investment on economic growth in Nigeria.

Empirically, the dynamic relationship between energy consumption, foreign direct investment, and economic growth in Sub-Saharan Africa was studied by Olanrele and Awode (2022). Data from 42 Sub-Saharan African nations between 1991 and 2018 are used in the study. The Generalized Method of Moments was used to examine the gathered data. According to the study's findings, a 1.3 percent rise in energy consumption results in 1.3 percent economic growth. On the other hand, economic expansion results in a 0.004% increase in energy use. Additionally, there is a strong one-way causal relationship between economic growth and foreign direct investment.

Cinar and Nulambeh (2018) investigated how trade openness and foreign direct investment affected the economic growth of 34 Sub-Saharan African nations. The study made use of panel data spanning the years 2006 through 2015. Panel regression analysis was used to examine the gathered data (Pooled, FE, and RE models). It was discovered that the RE model was more effective than the FE model. The study's conclusions demonstrated that trade openness and foreign direct investment have a beneficial impact on growth, whereas inflation has a negative effect.

In light of current global trade liberalization trends, Taiwo et al. (2022) investigated the effects of trade openness on the economic performance of a subset of Middle Eastern and North African nations, integrating aspects of domestic investments into the empirical research. This study made use of panel data. Fully Modified Ordinary Least Square and Dynamic Ordinary Least Square

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regression techniques were used to examine the collected data. The results of the investigation showed that the factors had a long-term association.

Gyimah et al. (2023) investigated how China's economic development and carbon emissions were affected by renewable energy, both directly and indirectly, between 1990 and 2021. The study used the Granger Causality Test and Partial Least Square Structure Equation Modeling. According to the study's conclusions, using renewable energy has no impact on economic growth but does increase carbon emissions. There are benefits to carbon emissions from both foreign direct investment and financial inclusion. Through economic expansion, renewable energy does, however, indirectly contribute to carbon emissions. FDI has a favorable impact on economic expansion.

Jia *et al*. (2023) use panel data from 90 Belt and Road nations from 2000 to 2019 to examine the direct and indirect effects of renewable energy usage on economic growth. Granger causality tests and mediating effect models were used in the study. The feedback hypothesis was further supported when it was found that there is a reciprocal causal relationship between the use of renewable energy and economic growth. The results demonstrated that the use of renewable energy directly supports economic expansion.

Abinabo and Abubakar (2023) examined the connection between Nigeria's economic growth and trade openness between 1990 and 2021. The Central of Nigeria Statistical Bulletin provided the study's data. Descriptive statistics, the Johansen Cointegration test for long-term relationships, the Error Correction Mechanism model for estimation, and the Augmented Dickey Fuller unit root test for stationarity were all used in the study. The findings show a long-term correlation between Nigeria's economic growth and trade openness, or the volume of imports, exports, and international commerce. Additionally, the results show that imports have a considerable negative influence on Nigeria's economic growth, while trade openness has a favorable and statistically significant benefit.

Using the Autoregressive Distributed Lag Bound approach, Olasehinde and Ajayi (2022) investigated the connection between foreign direct investment and economic growth in Nigeria from 1981 to 2020. The results showed that the variables used had a substantial long-term association. Real exchange rates and foreign direct investment had both short- and long-term, favorable effects on economic growth. Additionally, it was found that trade openness and interest rates had little short- and long-term effects on economic growth. Economic growth and foreign

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direct investment were shown to be bidirectionally causally related via Pairwise Granger Causality, indicating that these two variables have an impact on one another.

Bashir (2022) examines how foreign direct investment affects economic growth in Nigeria between 1986 and 2020. The author of the study focused especially on how the currency rate affects this relationship. The World Bank's World Development Indicator database and the Central Bank of Nigeria's 2021 Statistical Bulletin provided the study with annual time series data. The research was conducted using the Autoregressive Distributed Lag model. According to the study, foreign direct investment significantly and favorably affects economic growth. Economic growth is positively and significantly impacted by the exchange rate as well.

Using data from 1980 to 2016, Khobai et al. (2018) assessed the long-term correlation between trade openness and economic growth in Ghana and Nigeria. The autoregressive distributed lag model was used to evaluate the data. The study's conclusions indicated that there might be a long-term correlation between the variables for both nations. The findings also demonstrated that, in Ghana, trade openness has a positive and significant influence on economic growth at the 1% level, whereas in Nigeria, it has a negative but negligible effect.

Umeji et al. (2023) used data from 1990 to 2020 to analyze Nigeria's economic growth and use of renewable energy. The Toda-Yamamoto augmented Granger causality test (ARDL limits test) was used to evaluate the data in order to investigate how the use of renewable energy affects economic growth. A two-way association between the variables was discovered by the investigation. The findings of the regression also demonstrated that the use of renewable energy significantly boosted economic growth.

Azeakpono and Lloyd (2020) looked into how Nigeria's economic growth was affected by the use of renewable energy from 1990 to 2016. Regression, correlation, co-integration, and Granger causality tests were used to examine the study's data. The findings indicated that while Nigeria's economic growth and usage of renewable energy both rose between 1990 and 2016, there was no discernible beneficial relationship between the two. Additionally, during the study period, there was no correlation between Nigeria's economic growth and the use of renewable energy.

Prince et al. (2021) used the multivariate framework from 2000Q1-2018Q4, the Autoregressive Distributed Lag bounds test approach, the Error Correction Model (ECM), and the Clemente-Montanes-Reyes unit root for structural breaks in the series to examine the causal relationship

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between energy consumption and economic growth in Nigeria. A bidirectional and co-integrating relationship between petroleum, liquefied natural gas, and electricity usage was found in the study's conclusions.

Using the fixed and random effect models, Bakari and Sofien (2019) investigated the effects of trade openness, foreign investment inflows, and domestic investment on economic growth for the case of 24 Asian economies over the period 2002-2017. The study's conclusions showed that domestic investment had a favorable impact on economic expansion. Exports and foreign direct investment, however, are having a detrimental impact on the growth trajectory. Furthermore, there is no discernible relationship between economic growth and the population, imports, or final consumption spending.

Bukar and Adamu (2023) investigated the three-way relationship between Nigeria's economic growth from 1990 to 2021 and the final energy consumption of gasoline, trade openness, and foreign direct investment. ARDL was used in the study as the data analysis method. The calculated parameters for the short and long terms show that trade openness, FDI, and petroleum consumption all have an effect on Nigeria's economic growth over the short and long terms. The error correction term has a statistically significant negative coefficient. This suggests that the model is mean-reverting and that, in the event of disequilibrium, the short-run model tends to return to its long-run equilibrium value over time at a rate of 63% annually.

Dahal et al. (2024) investigated how foreign direct investment and trade affected Nepal's long-term economic development. From 1989–1990 to 2021–2022, secondary data is used in the study. This study used the fully modified least squares approach, the trace, and the max-eigen tests. There is consistent evidence of long-term co-integration between GDP and variables related to import, export, total trade, and foreign direct investment, according to the findings of the Trace and max-eigen tests. The GDP of Nepal is found to be negatively and statistically significantly explained by imports and exports. In a similar vein, foreign direct investment and overall trade volume had a favorable and substantial effect on GDP. The increase of Nepal's GDP is multiplied by foreign trade.

Akinwale (2021) uses the VECM to investigate the relationship between Nigeria's energy consumption, trade openness, and economic growth from 1971 to 2015. Because the three series are co-integrated, a long-term relationship has been established between them, according to the results of the Johansen co-integration test. VECM's causality study demonstrates that there is a

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long-term causal relationship between trade openness and economic growth and energy consumption, as well as between trade openness and economic growth and energy consumption. The Granger causality between economic growth and trade openness alone is demonstrated by the short-run causality data.

Using ARDL, Hao (2023) studied the long- and short-term dynamic interactions between China's industrial economic growth (IEG), capital formation (K), trade openness (TRO), and foreign direct investment (FDI) from 1990 to 2021. The findings of the ARDL co-integration tests indicate that the variables have a long-term co-integration relationship. It also supports the feedback hypothesis because TRO, FDI, and K all have positive impacts on IEG and vice versa. TRO and K, however, have a minor and negligible detrimental impact on IEG, which runs counter to the short-term association. Lastly, K and TRO have a positive impact on FDI, whereas FDI has a negative impact on K. However, this difference is small and insignificant at the 10% significance level. In contrast, they are ultimately unimportant.

Despite the numerous empirical literatures on this area, there is no specific study that the investigated the impact of these three variables (renewable energy consumption, trade openness, and foreign direct investment) on economic growth in Nigeria recently. Thus, this study seeks to add to the body of existing literatures on the impact of renewable energy consumption, trade openness, and foreign direct investment on economic growth in Nigeria using Vector Error Correction Model approach.

2.0 Materials and Methods

2.1 Materials

The data used in this study was secondary, collected from World Development Indicator (WDI). This involves consulting past records of the variables (energy consumption, trade openness, foreign direct investment and gross domestic product) under study.

2.2 Unit Root Test

The study adopted augmented Dickey Fuller (ADF) test and Phillips Perron (PP) test for unit root test.

The Augmented Dickey Fuller Test

Sometimes, time series data are not in a stationary form. To transform it into a stationary form, an easy way is to difference the time series data. One way is to use the Augmented Dickey-Fuller (ADF) t-statistic. The Augmented Dickey-Fuller (ADF) test is a statistical test used to determine

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the presence of a unit root in a time series data (Dickey & Fuller, 1979). The test is an extension of the Dickey-Fuller test, which includes additional lagged terms to account for any autocorrelation in the residuals (Said & Dickey, 1984).

The ADF test constructs a parametric correction for higher-order correlation by assuming that the y series follows an $AR(P)$ process and adding P lagged difference terms of the dependent variable y to the right-hand side of the test regression as follow:

$$\Delta y_t = \alpha y_{t-1} + x_t'\delta + \beta_1 \Delta y_{t-1} + +\beta_2 \Delta y_{t-2} + \cdots + +\beta_p \Delta y_{t-p} + v_t \quad (3.1)$$

where x_t are optional exogenous regressors which may consist of constant, or a constant and trend. The null hypothesis of the ADF t-test is:

$H_0: \theta = 0$

which means that the data needs to be differenced to make it stationary. The alternative hypothesis of

$H_1: \theta < 0$

which means that the data is trend stationary and needs to be analyzed by means of using a time trend in the regression model instead of differencing the data.

The test statistic is conventional t-ratio for α:

$$t_\alpha = \frac{\hat{\alpha}}{SE(\hat{\alpha})}$$

Where $\hat{\alpha}$ is the estimate of α and $SE(\hat{\alpha})$ is the coefficient of standard error.

Phillip's Perron Test

Phillips and Perron (1988) propose an alternative method of controlling for serial correlation when testing for a unit root called Phillips-Perron (PP) test. The PP test is a non-parametric test that is similar to the ADF test but does not require the specification of a particular model (Phillips & Perron, 1988). The PP method estimates the non-augmented Dickey-Fuller test equation:

$$\Delta y_t = \alpha y_{t-1} + x_t'\delta + \epsilon \quad (3.2)$$

It modifies the t-ratio of the α coefficient so that serial correlation does not affect asymptotic distribution of the test statistic. The PP test is based on the statistic:

$$\tilde{t}_\alpha = t_\alpha \left(\frac{\gamma_0}{f_0}\right)^{\frac{1}{2}} - \frac{T(f_0 - \gamma_0)SE(\hat{\alpha})}{2f_0^{\frac{1}{2}}S} \quad (3.3)$$

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where $\hat{\alpha}$ is the estimate of α, and t_α is the t -ratio of α, $SE(\hat{\alpha})$ is the coefficient standard error, and S is the standard error of the test regression. In addition, γ_0 is a consistent estimate of the error variance. The remaining term, f_0 is an estimator of the residual spectrum at frequency zero.

2.3 Johansen and Juselius Co-integration Test

For co-integration testing, the Johansen and Juselius Co-integration Test (the Maximum Eigenvalue test and the Trace test) is the most often used test (Johansen & Juselius, 1990). The number of co-integration vectors is ascertained by the Maximum Eigenvalue test and the Trace test.

The Maximum Eigenvalue statistic test the null hypothesis of r co-integrating relations against the alternative of $r + 1$ co-integrating relations for $r = 0, 1, 2, \ldots, n - 1$. This test statistic is computed as:

$$\lambda_{max} = (r, r + 1) = -Tln(1 - \hat{\lambda}_{r+1}) \quad (3.4)$$

Where $\hat{\lambda}$ is the computed maximum eigenvalues and T stands for the sample size.

The main difference between the maximum eigenvalue test and the trace test is that the trace test is the joint test, whereas the maximum eigen value test conducts separate test on the individual eigenvalues.

Trace statistic examines the null hypothesis of r co-integrating relations against the alternative of n co-integrating relations, where n is the number of variables in the system for $r = 0, 1, 2, \ldots, n - 1$.

It is computed according to the formula.

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln (1 - \hat{\lambda}_i) \quad (3.5)$$

The results of trace test should be should be chosen where trace and maximum eigenvalue statistic may yield different results in some case (Habte, 2014).

2.4 Vector Error Correction Model

In recent years, there has been a growing interest in the Vector Error Correction Model (VECM) for the analysis of multivariate non-stationary time series. The primary reason is that VECM enables researchers to characterize the interactions between non-stationary variables over both the short and long term (Raissi, 2010). The ability of the VECM to compensate for any imbalance that can occasionally shock the system is its primary characteristic. When such disequilibrium occurs, the error correction term detects it and returns the system's variables to equilibrium (Hossain, 2009).

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There are two major conditions that must hold before using the VECM. The are:

i. The variables should be stationary at first difference

ii. The co-integration between the variables must exists.

According to Pfaff (2008), the VECM specification is given as:

$$\Delta y_t = \alpha\beta^T y_{t-p} + \Gamma_1 \Delta y_{t-1} + \cdots + \Gamma_{p-1} y_{t-p+1} + V_t \quad (3.6)$$

With

$$\Gamma_i = -(I - A_1 - \cdots - A_i)$$

And

$$\pi = \alpha\beta^T = -(I - A_1 - \cdots - A_P)$$

The Γ_i matrices contain the cumulative long run impacts, hence this VECM specification is signified by long run from. The other specification is given as follows and is commonly used:

$$\Delta y_t = \alpha\beta^T y_{t-1} + \Gamma_1 \Delta y_{t-1} + \cdots + \Gamma_{p-1} y_{t-p+1} + V_t \quad (3.7)$$

$$\Gamma_i = -(A_{i+1} + \cdots + A_p)$$

And

$$\pi = \alpha\beta^T = -(I - A_1 - \cdots - A_P)$$

Hence, the π matrix is the same as in the first specification. However, the Γ_i matrices now differ, in the sense that they measure transitory effects. Thus, this specification is signified as transitory form. In the case co-integration, the matrix $\pi = \alpha\beta^T$ is of reduced rank. The dimension of α and β is $K \times r$ is the co-integration rank, that is, many long run relationships between the variables y_t do exist. The matrix α is the loading matrix and the coefficients of the long-run relationship are contained in β (Pffaf, 2008).

According to Adenomon and Michale (2017), the procedure for estimating VECM consist of three parts:

i. Testing for unit root, I(1) in each series

ii. Testing for number of co-integrating vectors in the system given that the null hypothesis of a unit root in the variables is not rejected.

iii. Estimating and testing for casualty in the framework of multivariate vector error correction model. If the variables are found to stationary in their level representation, then the standard vector autoregression (VAR) model is appropriate in detecting the direction of causality.

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2.5 Model Specification

The functional model for this study is stated as below:

$$\Delta GDPPC_t = \hat{A} + \sum_{i=1}^{p}[\delta_{1i}\,\Delta GDPPC_{t-i} + \beta_{1i}\Delta FDI_{t-i} + \varphi_{1i}\Delta REC_{t-i} + \omega_{1i}\Delta TO_{t-i}] + \mu_1\varepsilon_{t-1} + \gamma_{1t} \quad (3.8)$$

Where $\delta, \beta, \varphi\ and\ \omega$ are the coefficient of the lagged regressors while A is the constant term. GDPPC is gross domestic product per capita, FDI is foreign direct investment, REC is renewable energy consumption, TO is trade openness and ε is the error term.

3.0 Results

This section presents the results of data analysis. Preliminary analysis such as visualizing the data in graphical form and descriptive statistics and the results were presented as below:

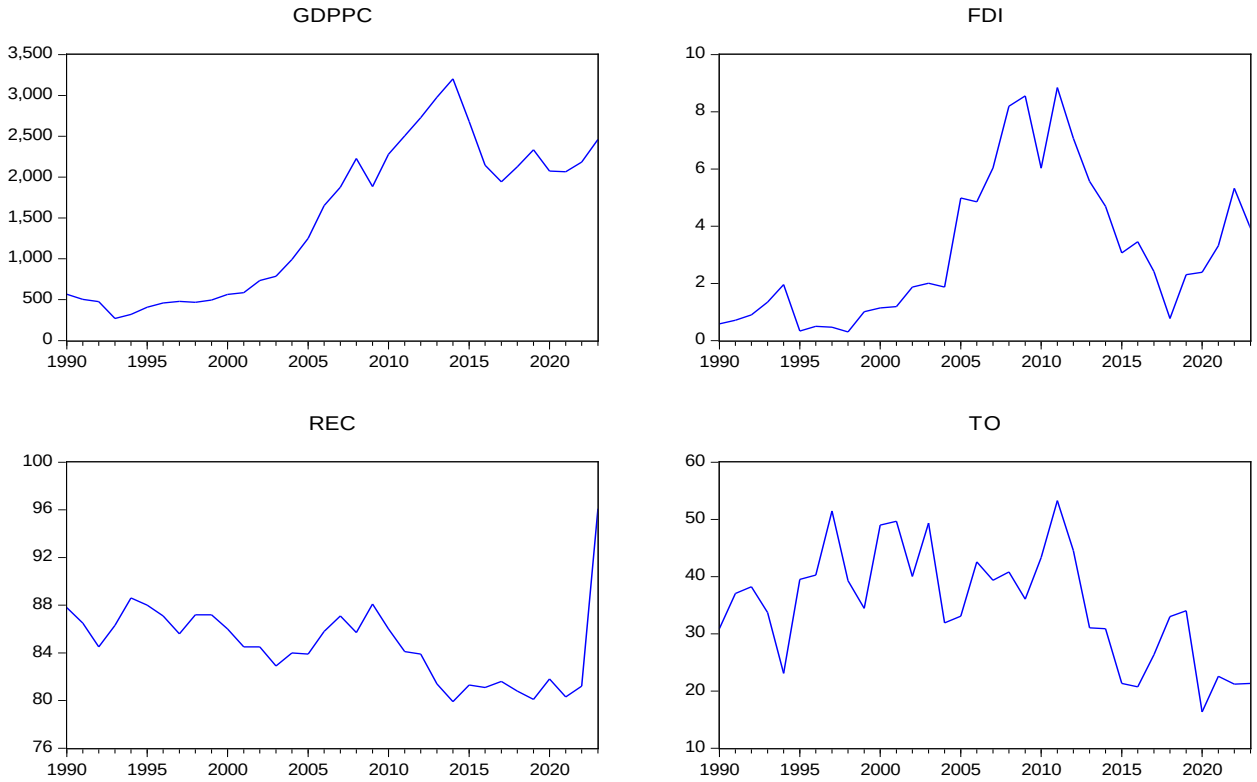

Figure 3.1: Graph of GDPPC, FDI, REC and TO

From figure 3.1, it was observed that gross domestic product per capita (GDDPC) exhibit a positive trend between 1990 to 2009 and fluctuates between 2010 to 2023. Also, the graph of foreign direct investment (FDI), renewable energy consumption (REC) and trade openness (TO) fluctuates throughout the study periods.

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Table 3.1: Descriptive Statistics Results

	GDPPC	FDI	REC	TO
Mean	1491.361	3.1755	84.7324	35.2842
Median	1764.283	2.3452	84.5000	35.2583
Maximum	3200.953	8.8412	96.1000	53.2780
Minimum	270.0275	0.2996	79.9000	16.3522
Std. Dev.	929.2975	2.5582	3.3182	9.7749
Skewness	0.099766	0.7756	0.9329	-0.0749
Kurtosis	1.518970	2.4794	5.1041	2.2311
Jarque-Bera	3.163791	3.7924	11.2034	0.8693
Probability	0.205585	0.1501	0.0037	0.6475
Sum	50706.27	107.9679	2880.900	1199.662
Sum Sq. Dev.	28498595	215.9590	363.3544	3153.100
Observations	34	34	34	34

Source: Computed using EVIEWs

Table 3.1 presents the descriptive statistics results for the variables under study. The mean gross domestic product per capita is 1491.361 USD with minimum and maximum value of 270.0275 and 3200.953 USD. Foreign direct investment has a mean value of 3 with minimum and maximum value of 0.2996 and 8.8412 respectively. Renewable energy consumption has a mean value of 84.7324 with minimum and maximum values of 79.900 and 96.1000 respectively. Trade openness have a mean value of 35.2842 with minimum and maximum value of 16.3522 and 53.2780 respectively. The results revealed further that all the variables under study with the exception of REC were normally distributed ($P > 0.05$). The number of observations is 34 which correspond to the study period 1990 – 2023.

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Table 3.2: ADF and PP Unit Root Result

Variables	Method	Order	Test Critical Values			Test Statistic	P-value	Remark
			1%	5%	10%			
GDDPC	ADF	0	-2.6392	-1.9517	-1.6106	0.4103	0.7958	Not stationary
		1	-2.6392	-1.9517	-1.6106	-3.8308	0.0004	Stationary
	PP	0	-2.6369	-1.9513	-1.6107	0.8206	0.8843	Not stationary
		1	-2.6392	-1.9517	-1.6106	-3.7788	0.0004	Stationary
FDI	ADF	0	-2.6443	-1.9525	-1.6102	-0.9617	0.2928	Not stationary
		1	-2.6569	-1.9544	-1.6093	-2.7794	0.0074	Stationary
	PP	0	-2.6369	-1.9513	-1.6107	-0.7461	0.3855	Not stationary
		1	-2.6392	-1.9517	-1.6106	-6.3804	0.0000	Stationary
REC	ADF	0	-2.6369	-1.9513	-1.6107	0.4261	0.8000	Not stationary
		1	-2.6392	-1.9517	-1.6106	-2.3694	0.0194	Stationary
	PP	0	-2.6369	-1.9513	-1.6107	0.4166	0.7976	Not stationary
		1	-2.6392	-1.9517	-1.6106	-2.3820	0.0188	Stationary
TO	ADF	0	-2.6417	-1.9521	-1.6104	-0.7736	0.3729	Not stationary
		1	-2.6417	-1.9521	-1.6104	-5.6624	0.0000	Stationary
	PP	0	-2.6369	-1.9513	-1.6107	-0.6358	0.4342	Not stationary
		1	-9.4372	-2.6392	-1.9517	-1.6106	0.0000	Stationary

Source: Extracted from EVIEWs Output

Table 3.2 presents the ADF and PP results unit root test for all the variables under study. The results from both tests (ADF and PP) revealed that all the variables were not stationary at level (p-values > 0.05). However, these series become stationary after first difference (p-value < 0.05). In table 3.3, the p-value= 0.0745 > 0.05 and is appeared under at most 1 were trace test indicate 1 co-integration equation at 0.05 level which implies that the variables are co-integrated. Hence, we accept H_1. Likewise, maximum eigenvalue indicates 1 co-integration equation which also shows that the variables exhibit long run relationship among them.

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Table 3.3: Co-integration test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.598073	57.42057	47.85613	0.0049
At most 1	0.381117	28.25309	29.79707	0.0745
At most 2	0.254499	12.89826	15.49471	0.1186
At most 3	0.103603	3.499913	3.841466	0.0614

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.598073	29.16748	27.58434	0.0311
At most 1	0.381117	15.35483	21.13162	0.2648
At most 2	0.254499	9.398345	14.26460	0.2545
At most 3	0.103603	3.499913	3.841466	0.0614

Source: EVIEWs output

Table 3.4: VAR Lag Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-470.6064	NA	1.93e+09	32.73148	32.92007	32.79054
1	-401.0042	115.2037*	48505226*	29.03477	29.97774*	29.33010*
2	-387.2103	19.02610	60615789	29.18692*	30.88425	29.71850
3	-368.6944	20.43136	61590241	29.01341	31.46511	29.78125
4	-347.1978	17.79026	63598978	28.63433	31.84041	29.63843
5	-324.1245	12.73012	91534769	28.14652	32.10696	29.38688

Source: EVIEWs output

Table 3.4 presents the Vector Autoregressive (VAR) lag selection criteria. The AIC criterion revealed the optimal lag to be 2 while LR, FPE, SC and HQ revealed optimal lag criterion to be 1.

Table 1: Long Run Estimate

Variables	Coefficient	Std Error	Test statistics	Remark
FDI	-241.1190	36.2802	-6.6460	Significant
REC	388.3511	55.5288	6.9937	Significant
TO	-70.1697	20.3444	-3.4490	Significant
Constant	-30912			

Source: EVIEWs output

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The results of long run estimate were presented in Table 3.5. The coefficients of the long run estimates revealed that FDI and trade openness have negative and significant impact on gross domes domestic product per capita in the long run while REC have positive and significant impact on gross domestic product per capita in the long run.

Table 3.6: Short Run estimates

	Coefficient	Std. Error	t-Statistic	Prob.
ECT(-1)	-0.235917	0.106228	-2.220857	0.0291
GDPPC(-1)	0.257637	0.220510	1.168371	0.2460
GDPPC(-2)	-0.076422	0.211064	-0.362080	0.7182
FDI(-1)	-29.15131	40.27920	-0.723731	0.4712
FDI(-2)	6.326374	42.20872	0.149883	0.8812
REC(-1)	111.3309	56.34315	1.975943	0.0414
REC(-2)	91.49865	46.02716	1.987927	0.0401
TO(-1)	-5.078941	6.170865	-0.823052	0.4128
TO(-2)	3.788895	5.393012	0.702556	0.4843
Constant	97.07647	46.18252	2.102017	0.0385
R-square	0.4034			
Adj. R-square	0.1477			

Source: EVIEWs output

Table 3.6 presents the short run estimated of the relationship between GDPPC, FDI, REC and trade oneness. The Error Correction Model ECT(-1) portrays the speed of adjustment required to restore equilibrium in the dynamic model from an innovation. It affirms a priori expectation as its coefficient is negative and has a p-value that is statistically significant at 5% level. The ECT(-1) value of -0.235917 implies that an impulse to gross domestic product per capita in the current period will be restored at a speed of adjustment of about 23.6% in the next period. This implies that 23.6% of the short-run disequilibrium is corrected annually. The R-squared (0.4034) indicates that the explanatory variables explained 40.34% of the variations in gross domestic product per capita in the short run. The renewable energy consumption at both lags (1 & 2) were positive and statistically significant ($p < 0.05$). This implies that renewable energy consumption contributes positively to gross domestic product per capita. However, FDI was found to be negative and statically insignificant at lag 1 while positive and statistically insignificant at lag 2 in the short run ($p > 0.05$). Similarly, trade openness has negative and statistically insignificant at lag 1 and positive and statistically insignificant at lag 2 in the short run ($p > 0.05$).

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Table 3.7: VEC Granger Causality/Block Exogeneity Wald Tests

Dependent variable: D(GDPPC)

Excluded	Chi-sq	df	Prob.
D(FDI)	0.787271	2	0.6746
D(REC)	6.170634	2	0.0457
D(TO)	1.203600	2	0.5478
All	11.04201	6	0.0871

From table 3.7, it revealed that D(FDI) and D(TO) do not Granger cause D(GDPPC) since their p-value > 0.05 while D(REC) Granger cause GDPPC since its p-value < 0.05. However, the three variables jointly do not Granger cause GDPPC.

Table 3.8: Variance Decomposition of GDPPC

Period	S.E.	GDPPC	FDI	REC	TO
1	221.3886	100.0000	0.000000	0.000000	0.000000
2	345.1416	94.15346	1.128888	0.699396	4.018254
3	478.4205	74.39526	9.700964	3.479806	12.42398
4	596.6821	60.85623	20.40149	2.504688	16.23759
5	681.0770	51.65657	25.11530	1.927891	21.30024
6	760.2242	45.21614	27.11053	1.857341	25.81599
7	830.7514	41.49747	29.75454	1.712111	27.03588
8	883.4508	38.97995	31.38743	1.517474	28.11515
9	931.7277	37.24225	31.70510	1.406751	29.64590
10	981.6369	36.27847	32.19147	1.380707	30.14935

Source: EVIEWs output

In Table 3.8 shows that at period 10, GDPPC explained itself by 36.3% while FDI, REC and TO explained GDP by 32.2%,1.4% and 30.1% respectively.

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Residual Diagnostics

Table 3.9: VEC Residual Normality Tests

Component	Jarque-Bera	df	Prob.
1	0.455187	2	0.7964
2	0.179036	2	0.9144
3	106.7826	2	0.0000
4	0.027623	2	0.9863
Joint	107.4444	8	0.0000

Source: EVIEWs output

The residual normality test results as presented in Table 3.9 indicates that the residuals are normally distributed at 1st, 2nd and 4th component (p-value = > 0.05). However, the residuals were not normally distributed at 3rd component.

Table 10: VEC Residual Serial Correlation LM Tests

Lag	LRE* stat	DF	Prob.	Rao F-stat	DF	Prob.
1	21.93907	16	0.1452	1.479448	(16, 43.4)	0.1519
2	13.62073	16	0.6269	0.841679	(16, 43.4)	0.6343
3	20.28046	16	0.2079	1.343746	(16, 43.4)	0.2157
4	11.51016	16	0.7770	0.695918	(16, 43.4)	0.7821
5	15.27344	16	0.5047	0.960157	(16, 43.4)	0.5132

Source: EVIEWs output

The results for VEC residuals serial correlation LM test was presented in Table 3.10. The results revealed that there is no serial correlation in the residual of the estimated VECM model at all lag (p-value > 0.05).

Table 3.11: VEC Residual Heteroskedasticity Tests

Chi-sq	df	Prob.
175.0682	180	0.5898

Source: EVIEWs output

The results of VEC residuals Heteroskedasticity Tests presented in Table 3.11 revealed that the variance of the residuals of the estimated VECM model are constant (p-value = 0.5898 > 0.05). This implies that there is no evidence of Heteroskedasticity in the residuals of the estimated model.

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4.0 Summary and Conclusion

This study modeled the impact of renewable energy consumption, trade openness, and foreign direct investment on Nigeria's economic growth using data from the World Development Indicators (1990–2023). A Vector Error Correction Model (VECM) analysis revealed that while foreign direct investment and trade openness negatively influenced GDP per capita in the long run, renewable energy consumption had a positive and significant effect both in the short and long run. The findings emphasize the importance of prioritizing renewable energy to sustain economic growth.

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