

Foreign Direct Investment, Industrial Output and Sustainable Development in Nigeria

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ABSTRACT: The current study investigates the dynamic relationship among foreign direct investment (FDI), industrial production and sustainable development in Nigeria, in view of the long-standing failure of the nation to translate the inflow of FDI into consistent industrial growth and inclusive sustainable development in spite of decades of liberalisation of FDI. Most literature is cross-country based, and does not account for country-specific, longitudinal and reciprocal dynamics. The study uses annual data spanning 1981-2024, and estimates a seven-variable Vector Error Correction Model containing a composite sustainable development index, industrial output, FDI, government expenditure, money supply, exchange rate and inflation. Four cointegrating vectors were detected by the Johansen trace test after all series were integrated of order one. The error correction term was (-0.713) which showed that the annual adjustment towards equilibrium was rapid. Industrial output shocks showed persistently negative short-run effects, while FDI had a negative long-run and lagged short-run effect on sustainable development, which is consistent with the Pollution Haven Hypothesis and Environmental Kuznets Curve. Nonetheless, FDI-inflows reacted positively to sustainable development shocks in following periods, accounting for more than half of the forecast error variance by period 10, which shows a true and proper bidirectional link. The study recommends ESG based screening of FDI; monetary discipline; competitive exchange rate management and environmentally related industrial policy as these are dynamic and reciprocal relationship between FDI and industries in Nigeria rather than unidirectional. The novelty of the study is the simultaneous dynamic modelling of the three variables in Nigeria.

KEYWORDS: Foreign direct investment, Industrial output, Sustainable development, Vector error correction model, Environmental Kuznets curve

1. INTRODUCTION

Foreign direct investment (FDI) remains the focal point of the development policies of resource-rich countries and their efforts to turn foreign capital into industrialization and sustainable development in general. FDI is a type of investment that involves an ownership stake (roughly 10% or more) and managerial control in an enterprise in another economy, where the investor has an interest in the other economy, thus distinguishing it from portfolio flow (Sikwane, 2025). Industrial output, measured by indices like manufacturing value added and the index of industrial production, reflects the dynamism and productive potential of mining, manufacturing and utilities industries and is strongly associated with job creation and structural changes. The concept of sustainable development, as framed in the Brundtland formulation and operationalised by the Sustainable Development Goals (SDGs), must ensure that current economic benefits do not erode the welfare of future generations, incorporating economic, social and environmental aspects of progress (Ninyio, 2025). The way in which these three phenomena interact is not mechanical and simple: FDI can, in principle, increase industrial capacity by bringing in capital, by transferring technology and by providing managerial spillovers etc., but whether this industrial expansion translates into sustainable outcomes depends on the composition of FDI in terms of sectors, the quality of regulatory institutions and the internalisation of environmental costs.

Nigeria provides a very telling context in which to look at this nexus. The introduction of FDI to the country can be traced to the colonial exploitation of extractive resources, which was later restricted by indigenisation policies in the 1970s, before being liberalized in the Structural Adjustment Programme of 1986 and the Nigerian Investment Promotion Commission Act (1995) (Simachenya & Haabazoka, 2025). The inflows have been erratic in history, averaging two to three billion United States dollars per year in the early 2000s, peaking in 2011 at 8.8 billion dollars, only for the oil price shocks and insecurity in the Niger Delta to bring

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back instability. Recent figures show that the relationship remains fragile as capital importation experienced a seventy per cent increase from 176.51 million United States dollars in the first quarter of 2024 to 126.29 million United States dollars in the first quarter of 2025, even though there was net out flow of FDI in 2022 with a partial recovery in 2023 (Ameyaw & Panibratov, 2025). The industrial sector has recorded some signs of recovery, as industrial production increased by 3.77 per cent during the third quarter of 2025 compared with 2.78 per cent in the previous quarter, and non-oil activities contributed significantly to the growth during the second quarter of 2025 when industrial production rose by 3.99 per cent compared with the corresponding quarter of 2024. Nigeria's implementation of the Sustainable Development Goals (SDGs) since domestication in 2015 is also uneven, with only 34.6 per cent of the indicators tracked showing improvement, while the same proportion is stagnant and the rest are in reverse, with poverty, unemployment and environmental pressures continuing to erode the welfare gains from economic growth.

These trends reveal a key and recurring challenge – Nigeria has failed to convert inflows of FDI into a stable and mutually reinforcing relationship between FDI and industrial output growth and development. The growth projections for 2025, which are largely dependent on the agriculture and industry and services sectors (National Bureau of Statistics, 2025), have not been uniform and the structural factors such as the lack of infrastructure, foreign exchange shortages and the continued reliance on crude oil are not conducive to investment diversion into the manufacturing and green sectors. The evidence on the FDI-industry-sustainability relationship in other countries is also mixed and situation-specific, making the task of designing policies to be based on experience elsewhere challenging. In Lithuania, FDI is shown to strongly correlate with exports and wages, as well as weakly with decreases in greenhouse gas emissions (Bagirzadeh et al., 2025). While FDI is linked to greater engagement in global value chains and poverty reduction in Sub-Saharan Africa, industrial configurations with high shares of extractive industries often undermine the environmental gains that would otherwise accrue from information and communication technology and innovations (Manu & Asongu, 2025; Osabohien et al., 2025). Using a difference-in-differences design, Deng et al. (2024) find that FDI increases product innovation and industrial production of Chinese manufacturing companies by around a fifth.

One common limitation in this literature is that it relies on macro-level, cross-country panel evidence that obscures country-specific institutional arrangements and that very rarely examines the causal pathway from FDI to industrial production to sustainability outcomes in a single time series over a historical span. Both reviews of the FDI-emissions relationship in developed and developing economies (Essandoh et al., 2020) and the FDI-emissions-fuel-energy nexus in Europe and Central Asia (Mohsin et al., 2022) advise for country-specific longitudinal analysis that is able to capture the sectoral and institutional dampening effect that is averaged out by panel estimators. The existing literature on the impact of exchange rate fluctuations on FDI flows in oil-exporting countries (Abere & Ojo, 2025), however, underscores the relevance of macroeconomic conditions, but falls short of jointly modelling FDI, industrial production, and a composite indicator of sustainable development in a dynamic framework that allows for feedback effects. Evidence on trade-integration from the ECOWAS region also suggests that openness and cross-border economic linkages – of which FDI is a part of – are correlated with higher growth (Abere & Ogunwale, 2026), while broader panel evidence from Central Africa shows that industrialisation and structural variables interact with governance and finance to influence growth outcomes (Mbani, 2026). Another gap is that industrial output is treated as an add-on that does not interact with FDI and sustainability indicators dynamically, and thus can be ignored in the modelling analysis; the application of an EKC-STIRPAT-VECM framework to the Nigerian carbon emissions indicates that these interactions can actually vary over different time horizons (Adebanjo et al., 2026). The plausible cointegrated nature of FDI, industrial output and sustainable development suggests that they are jointly determined and that there is bidirectional causality between them, which is not directly appropriate to a one-directional regression framework, and therefore a system-based dynamic approach that is able to distinguish long-run equilibrium relationships from short-run adjustment dynamics is necessary.

These prompted the beginning of this study, which aimed at exploring the dynamic relationship between foreign direct investment, industrial output and sustainable development in Nigeria from 1981 to 2024. Specifically, the study investigates whether the three variables, namely FDI, industrial output and sustainable development, are in a long-run equilibrium relationship; the direction and strength of short-run and long-run causal linkages among the three variables and a set of macroeconomic controls such as government expenditure, money supply, the exchange rate and inflation; and the dynamic responses of the three variables to shocks emanating from within the system and the relative contribution of each variable in the forecast error variance of the other. To achieve these objectives, the study asks the following questions: are foreign direct investment, industrial output and sustainable development cointegrated in the Nigerian economy; what are the short and long run causal relationships between these variables; and how do shocks to any of these variables ripple through the system over time to affect the other?

The study has several contributions not just a rehash of the existing cointegration exercise. First, it offers a real long-run, single country time series analysis of the FDI-industry-sustainability nexus in Nigeria over three and a half decades across structural turning points (such as the Structural Adjustment Programme, the return to democratic governance, the 2008 global financial crisis, the 2016 and 2020 recessions and recent pandemic reforms), thereby responding to literature's call for country-specific longitudinal evidence (Essandoh et al., 2020; Mohsin et al., 2022). Second, the study develops a composite index of sustainable development which includes the economic, social and environmental dimensions of sustainable development by adjusting the three measures of

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sustainable development (adjusted net savings, ecological footprint relative to biocapacity, and Human Development Index) into a principal component index. Thirdly, the study includes FDI, industrial output and sustainable development in a seven-variable Vector Error Correction Model which includes government expenditure, money supply, the exchange rate and inflation, thus allowing the study to capture both the long-run cointegrating equilibrium and the short-run adjustment dynamics, while Granger causality, impulse response and forecast error variance decomposition evidence are also obtained and used in combination to determine if FDI and sustainable development in Nigeria are unidirectional or reciprocal. Fourth, the study provides an empirical test of applicability of the Eclectic Paradigm and the Pollution Haven Hypothesis which were hitherto used to explain the behavior of FDI in the advanced or rapidly industrializing economies to a resource-dependent developing economy where FDI historically has been concentrated in the extractive activity. The results aim to provide evidence-based recommendations for policymakers who want to ensure that FDI attraction strategies, industrial policy and macroeconomic policy are aligned with Nigeria's journey towards the 2030 Sustainable Development Goals.

2. LITERATURE REVIEW

2.1 Theoretical Review

This study is built on the theoretical framework of Dunning's Eclectic Paradigm, also referred to as OLI framework, which was first introduced in 1976 and further developed and simplified over the decades to answer the question as to why, where and how multinational enterprises internationalise their operations via foreign direct investment (Dunning, 2001). The paradigm assumes that FDI can only be the result of a firm possessing both Ownership advantages, which might be the result of a proprietary technology, brand equity or managerial expertise; and Location advantages, stemming from the host economy (natural resources, size of the market or favourable policy incentives); and that there are Internalisation advantages to be gained from keeping these assets within the firm rather than licensing them to independent local firms. When applied to Nigeria, the paradigm supports the explanation of the historical evidence that FDI has tended to gravitate towards the extractive industries that have strong location specific advantages such as crude oil and solid minerals, while manufacturing and technology-intensive FDI, which has a high requirement for complementary ownership specific advantages to be transferred and absorbed locally has been relatively limited. Despite the many extensions of the paradigm to digital platform multinationals (Luo, 2021), its essentially static nature underestimates the dynamic and path-dependent nature of internationalisation strategy in rapidly changing global value chains (Wagner, 2020).

The Pollution Haven Hypothesis (PHH) of Copeland and Taylor (1994, 2004) suggests that capital-exporting economies with high environmental standards will shift pollution-intensive activities to weakly regulated developing economies, meaning that FDI inflows into developing economies with weak environmental standards come with a systematic pollution price. This hypothesis is in contrast to the Pollution Halo Hypothesis which suggests that FDI can also share better environmental management practices and cleaner production practices to the host economy from the investing firm and hence improve the environmental outcomes. Such conflicting predictions exist in the literature because the net impact of FDI on the host country's sustainability is dependent on the sectoral composition of investment and the on the level of absorptive capacities of the domestic industry and the stringency of the domestic regulations, which are very different across countries and over time. Given the historically high share of FDI in Nigeria, particularly in the extractive sector, in a relatively weak regulatory context, the unconditional theoretical prediction is that FDI-spurred industrial growth can generate adverse environmental and social effects even if it ultimately enhances long-run development prospects through capital accumulation, employment generation and revenue.

A more recent theory to provide a way of understanding the dynamic link between industrial growth and sustainability is the Environmental Kuznets Curve hypothesis. The hypothesis states that there is an inverted-U relationship between economic or industrial activity and environmental degradation: when industrial development is at low levels, an increase in industrial activity is accompanied by an increase in resource depletion and pollution, but when income and capability of industry reaches a threshold, the increase in industrial activity is accompanied by improvement in environmental conditions due to the adoption of cleaner technologies and better institutional environment (Grossman & Krueger, 1995; Stern, 2004). Theoretically, industrial output growth may negatively affect sustainable development in the short run despite the fact that in the long run, classical structural-transformation theory (Lewis 1954; Rostow 1960) suggests that a positive relationship may exist once industrialisation has reached its full fruition through higher value-added, less resource-intensive production. In combination, the above theories (Eclectic Paradigm, Pollution Haven Hypothesis and Environmental Kuznets Curve) give complementary theoretical bases for expecting the FDI-industry-sustainability relationship in Nigeria to vary across time horizons in a manner that is directly testable within the frame of the Vector Error Correction Model used in this study.

2.2 Empirical Review

While there is a growing empirical literature on the interaction between FDI and industrial activity on the environment and development, results have been divergent and the importance of the country-specific and dynamic approach used in this study cannot be overemphasized. Geographically, there are a number of studies that focus on Sub Saharan Africa. Osabohien et al. (2025) investigate the role of FDI-induced GVC participation in sustainable industrial output and poverty reduction in SSA from 2005 to

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2022, finding that it positively impacts sustainable industrial output and lowers poverty, but cautioning against potential endogeneity issues and suggesting instrumental-variable strategies. Manu and Asongu (2025) also observe the moderating effect between industrial structure and environmentally sustainable development in the sub-region through the lenses of information and communication technology and green innovation.

A second set of studies looks at the Asian economies, which are also interesting because of similar resource- and institutional-dependent traits with the Nigerian economy. Elimam and Alattas (2025) apply a structural equation model from 2015 to 2024 in emerging Asian markets, and report that FDI increases industrial outcomes by about eighteen per cent, through technology transfer, which is rather high compared to the estimates for African economies, and the authors observe this is likely due to more developed absorptive capacity, while also finding the effect to be higher with strong institutional strategies, and aligned with SDG oriented growth. Deng et al. (2024) compare the impact on product innovation and industrial output of FDI with non-FDI firms in China from 2015 to 2023 and find that FDI increased the former and the latter by approximately 15 per cent, but with a caution not to extrapolate their results from the firm level to the macro level. Using a two-way fixed-effects panel model, Fu and Liang (2025) show that, in fact, the quality of FDI, not its quantity, is what is important for sustainable development outcomes, as industry heterogeneity and regional market mechanisms determine the impact strength of the quality of FDI based on Chinese firm-level data from 2011 to 2022.

The third strand of the literature is methodologically related to that used in this study and deals specifically with the relationship between FDI and emissions. Bagirzadeh et al., (2025) find that in Lithuania, FDI has a strong positive relationship with exports and wages and only a weak positive relationship with the decrease in greenhouse gas emissions, revealing that positive economic impacts of FDI do not necessarily carry over to environmental benefits. Famanta et al. (2024) use Feasible Generalised Least Squares and Panel Corrected Standard Errors with Lasso variable selection to apply to less developed countries between 2003 and 2021, and find a U-shaped relationship, where environmental load capacity first improves, and then declines after a certain threshold. From the methodological point of view these studies all show a movement away from ordinary least squares estimation with stationary macroeconomic series towards cointegration and panel-robust estimation methods that allow for non-stationary macroeconomic series, which is the same in the case of the Vector Error Correction approach followed here.

Another set of studies, albeit smaller, has started to challenge the intermediary and feedback mechanisms between FDI, industrialisation and sustainability, which is most pertinent to the aim of the current study. The study by Xue et al. (2024) examines how outward FDI and manufacturing sustainability is related in China between 2008 and 2017, revealing that technological progress and trade openness mediate and complement the relationship, while Mbani (2026) using a panel Vector Error Correction framework on Central African economies, documents that industrialisation, electricity access and governance jointly and dynamically shape growth outcomes, which provides methodological precedent for the multivariate VECM system estimated in this study. Adebajo et al. (2026) employ an Environmental Kuznets Curve-STIRPAT specification, VECM and artificial neural network robustness check to model the relationship between technological innovation and carbon emissions in Nigeria and provide direct evidence that dynamic, cointegration-based frameworks are well suited to capture the short-run and long-run divergence in Nigerian environment-industry relationships being investigated in this study. Indeed, Abere and Ogunwale (2026) use disaggregated trade data for ECOWAS economies, and their findings show that deeper trade integration, as a channel that is closely associated with the FDI, can foster economic expansion through technology transfer and market access, lending credence to the theoretical expectation that openness related capital flows can influence industrial and developmental path of West African countries. Finally, at the macro level of analysis of Nigeria, Abere and Akinbobola (2020) demonstrate that the macroeconomic performance depends on both external shocks and institutional quality, which underscores the importance of the inclusion of this study's control variables such as exchange rate, money supply, government expenditure and inflation dynamics in untangling the FDI-industry-sustainability relationship from the general macroeconomic volatility.

A comparison and analysis of this literature shows three common trends that warrant the empirical design of the present study. Geographically, the first difference is that African studies (Osabohien et al., 2025; Manu & Asongu, 2025) generally yield weaker FDI-industry linkages with more environmentally costly FDI, as compared to Asian studies (Deng et al., 2024; Elimam & Alattas, 2025; Fu & Liang, 2025), usually attributed to differences in institutional quality, absorptive capacity, and the sectoral composition of inward investment. Second, methodologically, the field has increasingly moved away from the use of static panel regressions to the use of cointegration-based dynamic estimators, such as ARDL, VECM, DOLS and FMOLS (Adebajo et al., 2026; Mbani, 2026), acknowledging that FDI, industrial output and sustainability indicators are non-stationary and mutually endogenous, and not suitable for cross sectional analysis in a single equation. Third, with regards to findings, while the FDI-sustainability relationship has been shown to be time-varying by an increasing number of studies with an implication that in the short run, the FDI-sustainability relationship may be negative or environmentally costly, the same may not hold in the longer run once the technology diffusion and institutional adaptation is completed, this study attempts to formally test the time-varying nature of the FDI-sustainability relationship for Nigeria using thirty-five years of annual data embedded in a dynamic VECM system, with the new combination of

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impulse response and variance decomposition analysis, which is not used in previous studies to the knowledge of the researcher in a jointly modelled FDI-industry-sustainability system.

3. METHODOLOGY

3.1 Model Specification

Following the Eclectic Paradigm and Environment Kuznets Curve logic presented in Section 2, this study assumes that sustainable development, industrial output and FDI are mutually and dynamically determined in a single macroeconomic system and none of them are strictly exogenous. The system is represented by the following implicit functional form:

$$SD = f(FDI, IND, GEXP, MS, EXC, INF) \quad (1)$$

SD is the composite sustainable development index, FDI is the net foreign direct investment inflows, IND is industrial output, GEXP is government expenditure, MS is broad money supply, EXC is the exchange rate and INF is the inflation rate. The long-run cointegrating relationship is explicitly expressed in the econometric form as follows and is estimated in the Vector Error Correction framework:

$$SD_t = \beta_0 + \beta_1 FDI_t + \beta_2 IND_t + \beta_3 GEXP_t + \beta_4 MS_t + \beta_5 EXC_t + \beta_6 INF_t + \varepsilon_t \quad (2)$$

All variables, except the inflation rate, are included in the estimated system in natural log form, and the inflation rate is kept in percentage form because of the presence of values close to and below zero in some periods, which reduces heteroskedasticity and dampens the impact of extreme observations and allows the estimated coefficients of FDI, industrial output and the other controls to be interpreted directly as elasticities. The logarithmic specification is written as

$$\ln SD_t = \beta_0 + \beta_1 \ln FDI_t + \beta_2 \ln IND_t + \beta_3 \ln GEXP_t + \beta_4 \ln MS_t + \beta_5 \ln EXC_t + \beta_6 \ln INF_t + \varepsilon_t \quad (3)$$

The Johansen procedure does not require a single dependent variable and hence the VECM does not require the specification of the single dependent variable; instead, the cointegrating vector normalised on sustainable development, in addition to the vector error correction equations for the industrial output and FDI, jointly describe the equilibrium and adjustment dynamics between the three core variables of interest. The vector error correction for the sustainable development equation is:

$$\begin{aligned} \Delta SD_t = & \alpha_0 + \lambda ECT_t - 1 + \Sigma \phi_i \Delta SD_t - i + \Sigma \theta_i \Delta IND_t - i + \Sigma \delta_i \Delta FDI_t - i + \Sigma \psi_i \Delta GEXP_t - i + \Sigma \phi_i \Delta MS_t - i \\ & + \Sigma \kappa_i \Delta EXC_t - i + \Sigma \rho_i \Delta INF_t - i \\ & + u_t \end{aligned} \quad (4)$$

where $ECT_t - 1$ is lagged error correction term from long-run cointegrating relationship, λ is the speed of adjustment in correcting the deviations from the long-run equilibrium each period and the sum of the difference terms captures short-run dynamics. In the same system, the short run dynamics of industrial production and FDI are governed by analogous VECM equations.

3.2 Estimation Technique

The estimation is done in five phases. First, stationarity of all seven series are tested using both the Augmented Dickey-Fuller test (Dickey & Fuller, 1979, 1981) and the Phillips-Perron test (Phillips & Perron, 1988) at level and first difference with and without constant, with constant and trend, and without constant and trend, because the validity of the Johansen cointegration procedure requires that series be integrated of a common order, usually $I(1)$. Second, having confirmed that the series are integrated of order one, the Johansen (1995) trace and maximum-eigenvalue tests are used to identify how many cointegrating vectors exist among the seven variables, with a linear deterministic trend specification, and an optimal lag interval selected by the Akaike and Schwarz information criteria. Third, once cointegration is found, the Vector Error Correction Model is estimated to find both the long-run cointegrating coefficients normalised on sustainable development as well as the short-run adjustment dynamics represented by the error correction term and the lagged first difference terms for each of the variables in the system. Finally, within the VECM framework, Granger causality tests are performed along with Impulse Response Functions and Forecast Error Variance Decomposition based on Cholesky factorisation with the ordering sustainable development, industrial output, FDI, to describe the direction, size and persistence of dynamic relationships among the core variables over a forecast horizon of 10 periods. Fifth, a large set of post-estimation diagnostic tests is performed, including VEC residual heteroskedasticity, residual normality and lag exclusion tests, to assess the statistical adequacy and reliability of the estimated system. As control variables, government expenditure, money supply, exchange rate and inflation are kept throughout as determinants of sustainable development in a macroeconomic context.

3.3 Pre-Estimation Considerations

Before estimation the study checks the order of integration for all the series because the Johansen procedure is not valid if the variables are integrated at different orders or if any of the series is stationary at level, $I(0)$, or integrated of order two, $I(2)$. The descriptive properties of each series (skewness, kurtosis and Jarque-Bera normality statistic) are also discussed to detect possible outliers or non-normality that may affect the cointegration and VECM estimates to follow. The length of the lags for the unit root tests and for the VECM are determined according to the Akaike Information Criterion and the Schwarz Criterion, respectively,

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which try to capture the dynamic structure of the data while avoiding the sacrifice of degrees of freedom typical of annual time series of moderate length.

3.4 Post-Estimation Diagnostics

After estimating the VECM, the study tests the statistical reliability of the system by conducting a joint VEC residual heteroskedasticity test that tests if the variance of the residuals is constant across observations and a VEC residual normality test based on Cholesky (Lütkepohl) orthogonalisation that tests the skewness and kurtosis properties of the multivariate residuals individually and jointly. The appropriateness of the selected values of lag is tested using lag exclusion Wald tests and the direction of the short run predictive causality between sustainable development and industrial output and FDI is established using the Granger causality (block exogeneity) test. These diagnostics taken together make sure that the standard errors and the t-statistics and probability values reported for the cointegrating vector and the short-run VECM coefficients are valid and inferences from the impulse response and the variance decomposition analysis are not affected by residual misspecification.

3.5 Variable Measurement and Sources of Data

The study utilizes data for Nigeria from the World Bank, World Development Indicators, the Central Bank of Nigeria Statistical Bulletin, and the National Bureau of Statistics on Nigeria from 1981 to 2024, with some data from the United Nations Conference on Trade and Development (UNCTAD) on FDI flows. Foreign direct investment (FDI) consists of equity capital, reinvested earnings and intra-company loans, and is measured as net inflows in current United States dollars. Industrial output (IND) is proxy as real manufacturing value added, which is an indicator of capacity utilization in manufacturing, mining and utilities. Sustainable development (SD) is built as a composite index, using Principal Component Analysis (PCA) with three indicators: Adjusted Net Savings (ANS) (which reflects the level of genuine savings after considering the depletion of natural resources and the investment in human capital); the Ecological Footprint (EF) relative to Biocapacity (which reflects the extent to which the resources consumed exceed the capacity of the domestic environment to replenish them); and the Human Development Index (HDI) (which reflects the social and human welfare outcomes). Government expenditure (GEXP) is defined as the sum of all federal, state and local recurrent and capital expenditures. Money supply (MS) is measured using the broad money (M2) which includes currency in circulation, demand deposits and time and saving deposits. EXC is the average annual value of Naira to US Dollar in the year measured, which is an indicator of the external competitiveness of the domestic economy. The inflation rate (INF) is the annual change in the Consumer Price Index, which reflects the decline in the purchasing power of money and macroeconomic instability.

3.6 A-Priori Expectations

Expected signs of the relationships between the dependent variable (sustainable development) and each explanatory variable, a-priori, are reported in Table 1, based on the theory and the empirical literature examined in Section 2.

Table 1: A-Priori Expectations

Variable	Measurement	Expected Sign on Sustainable Development
FDI	Net FDI inflows (current US\$)	+ (long run) / Ambiguous (short run)
IND	Real manufacturing value added	+ (long run) / – (short run)
GEXP	Aggregate government expenditure	+
MS	Broad money supply (M2)	+ / –
EXC	Naira per US dollar exchange rate	+
INF	Annual percentage change in CPI	–

4. RESULTS AND DISCUSSION

4.1 Pre-Estimation Results

4.1.1 Descriptive Statistics

Descriptive statistics of the seven variables used in the study for thirty-five annual observations are presented in Table 2. The mean value of industrial output was 54155.98, with a minimum value of 47890.70 and a maximum value of 60308.55, which shows moderate fluctuation over the sample period. The mean of sustainable development as a composite index was close to zero (2.86E-08) as is done with the standardisation procedure in Principal Component Analysis, but the standard deviation of the composite index (1.41) shows high variability around this mean. Average FDI inflow was 12,045.20 and the standard deviation was 4,797.24, indicating the well reported volatility of FDI inflow in Nigeria. The means for government expenditure and money supply were significantly larger at 140,565.5 and 411,353.4 respectively, and the standard deviations were also quite large, reflecting the decades of expansionary fiscal and monetary policies. The average inflation in that period was 18.71 per cent, peaking at an extreme 72.84 per cent. Skewness statistics show that most series are only weakly skewed, but that inflation is highly skewed (2.07), which means that there are some extreme inflationary episodes. The kurtosis values of most of the variables are less than three indicating

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platykurtic distribution and government expenditure and inflation show mild leptokurtosis. The Jarque-Bera probability values are above the usual five per cent level for all of the variables except inflation, which indicates the approximate normality of the remaining variables and the use of the following cointegration analysis.

Table 2: Descriptive Statistics of Study Variables

Statistic	IND	SD	FDI	EXC	GEXP	INF	MS
Mean	54155.98	2.86E-08	12045.20	2.0276	140565.5	18.706	411353.4
Median	54647.24	0.254976	10962.01	2.1182	135309.2	13.007	371530.0
Maximum	60308.55	2.215628	20879.11	3.1700	334302.4	72.836	955480.8
Minimum	47890.70	-2.072529	4800.587	0.9052	32244.08	5.3880	47102.09
Std. Dev.	3745.65	1.410858	4797.237	0.5342	74325.32	15.869	296972.7
Skewness	-0.157	-0.180	0.305	-0.398	0.768	2.071	0.362
Kurtosis	1.676	1.601	1.925	2.601	3.311	6.496	1.715
Jarque-Bera	2.700	3.044	2.231	1.156	3.581	42.851	3.171
Probability	0.259	0.218	0.328	0.561	0.167	0.000	0.205

4.1.2 Unit Root Tests

The Augmented Dickey-Fuller and Phillips-Perron tests are employed in level and first difference of all seven logarithmic series to ensure the validity of the Johansen cointegration tests, which are based on the assumption that all the series are integrated of the same order, and in the specification with constant. The results are presented in table 3. None of the series is stationary at level, as the Augmented Dickey-Fuller t-statistics fall between -2.129 (for LFDI) and -0.937 (for LIND) with the probability well above the five per cent significance level in all cases, suggesting that the null hypothesis of a unit root cannot be rejected. All series, however, become stationary at the first difference with all Augmented Dickey-Fuller t-statistics significant at the one or five per cent level, ranging from -3.016 for LMS to -7.541 for LSD. These results are confirmed by the Phillips-Perron statistics, which also indicate that all seven series are integrated of order one, I(1). This uniform order of integration meets the pre-condition for Johansen cointegration testing and suggests that tests for long-run equilibrium relationships between the variables be carried out.

Table 3: Unit Root Test Results (ADF and PP Tests, With Constant)

Variable	ADF Level	ADF 1st Diff.	PP Level	PP 1st Diff.	Order
LSD	-1.211 (0.658)	-7.541*** (0.000)	-1.123 (0.695)	(0.000)***	I(1)
LIND	-0.937 (0.764)	-4.813*** (0.001)	-0.937 (0.764)	(0.001)***	I(1)
LFDI	-2.119 (0.239)	-6.672*** (0.000)	-2.011 (0.281)	(0.000)***	I(1)
LEXC	-0.656 (0.845)	-4.585*** (0.001)	-0.680 (0.839)	(0.001)***	I(1)
LGEXP	-1.671 (0.436)	-6.813*** (0.000)	-1.554 (0.495)	(0.000)***	I(1)
LINF	-2.129 (0.235)	-4.657*** (0.001)	-2.437 (0.140)	(0.001)***	I(1)
LMS	-2.216 (0.205)	-3.016** (0.044)	-3.753*** (0.008)	(0.044)**	I(1)

Note: *** and ** denote significance at the 1% and 5% levels respectively. Values in parentheses are probability values.

4.1.3 Johansen Cointegration Test

After confirming that all series are I(1), the authors employ the Johansen trace test on a system of 33 adjusted observations, with a linear deterministic trend and a lag of one to one based upon the Akaike and Schwarz information criteria. The results of the trace statistics are shown in Table 4. The null hypothesis of no cointegrating relationship is firmly rejected, at the 159.914 level (trace statistic) which is far below the five per cent critical value of 125.615 ($p = 0.0001$). The hypotheses of at most one, two and three cointegrating vectors can also be rejected, with trace statistics of 113.816, 77.093 and 48.350, all of which are larger than the critical values. The test does not reject the hypothesis at most four cointegrating vectors (trace statistic = 27.769, $p = 0.084$), suggesting that there are exactly four cointegrating relationships between the 7 variables at the five per cent level of significance. This maximum-eigenvalue statistic, while less decisive, as is often the case when using an eigenvalue specific test, is given priority in accordance with the literature in the cointegration arena (Johansen & Juselius, 1990; Engle & Granger, 1987). Since more than one cointegrating vector has been confirmed, it can be said that sustainable development, industrial output, FDI and the four macroeconomic controls are linked in the long-run equilibrium, thus spurious regression does not exist and the use of Vector Error Correction Model for estimating long-run and short-run dynamics is justified.

Table 4: Johansen Cointegration Test (Trace Statistic)

Hypothesised CE(s)	No. of	Eigenvalue	Trace Statistic	0.05 Value	Critical	Prob.**
None *		0.7526	159.914	125.615		0.0001
At most 1 *		0.6714	113.816	95.754		0.0016
At most 2 *		0.5815	77.093	69.819		0.0117
At most 3 *		0.4640	48.350	47.856		0.0449
At most 4		0.4221	27.769	29.797		0.0842
At most 5		0.1770	9.671	15.495		0.3069
At most 6		0.0936	3.241	3.841		0.0718

4.2 Post-Estimation Results

The model estimates for the vector error correction are given below:

Since the presence of cointegration is confirmed, the VECM is estimated for the period 1993 to 2024 (thirty-two adjusted observations) with government expenditure, money supply, the exchange rate and inflation still controlled. The estimated cointegrating equation and short-run dynamics of the sustainable development equation is shown in Table 5. The normalised long run cointegrating vector shows a positive but statistically insignificant coefficient on industrial output of 3.572 (t-statistic = 1.443) and a negative and highly significant coefficient on FDI of -2.054 (t-statistic = -9.788). On a simple face, the negative long run VECM coefficient perhaps indicates that, after the full system dynamics, other things kept constant, sustained inflows of FDI have historically been associated with a worsening in Nigeria's composite sustainable development index, consistent with the Pollution Haven Hypothesis, and reflecting the extractive orientation of much of Nigeria's inward investment. The error correction term is statistically significant with a negative coefficient of -0.713, which means that about 71.3 per cent of any deviations of sustainable development from their long-run determinants is corrected within a year, a relatively rapid speed of adjustment compared to the -0.40 to -0.80 range of reportable similar macroeconomic models of Nigeria and African sustainable development outcomes (Adedoyin et al., 2020).

Table 5: Vector Error Correction Model (VECM) Estimates (Dependent: LSD)

Cointegrating Equation / Short-Run Term	Coefficient	Std. Error	t-Statistic
LIND(-1) [long-run, normalised on LSD]	3.572	2.475	1.443
LFDI(-1) [long-run, normalised on LSD]	-2.054	0.210	-9.788***
Constant (long-run)	-19.644	--	--
Error Correction Term (ECT)	-0.713	--	(significant)
D(LFDI(-2)) [short-run]	-0.797	0.297	-2.685**
D(LMS) [short-run]	-2.359	0.677	-3.487***
D(LEXC) [short-run]	1.259	0.395	3.184***
R-squared / F-statistic / AIC / SC	0.591	F=2.631	AIC=1.010, SC=1.560

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

Of the short-run dynamics, only the second lag of FDI has a negative and statistically significant coefficient -0.797 (t-statistic = -2.685, p = 0.021), which indicates that two years before a FDI investment, SD outcomes are worse. This could be a result of environmental and social costs, such as ecological degradation and depletion of resources in extractive areas, being manifested after the initial investment, just as the lagged negative effects of FDI are. As predicted, the short-run effect of money supply on sustainable development is negative and significant (coefficient = -2.359, t-statistic = -3.487, p = 0.003), and the implication is that money supply expansion is due to deficit financing and not to productivity growth, which causes inflation that disproportionately affects the welfare of the poor. The exchange rate is positively and significantly at the short-term level with a coefficient value of 1.259 (t-statistic = 3.184, p = 0.006) implying that naira depreciation is related to an improvement in sustainable development, likely because of the positive competitiveness of tradable sectors and import-substitution effects. No significant role is found for government spending and inflation in the short-run equation, indicating that their effects on sustainable development are mostly of structural nature. The R-squared is 0.591, the F-statistic equals 2.631, and the Akaike (1.010) and Schwarz (1.560) information criteria support the model specification.

4.2.2 Forecast Error Variance Decomposition

Forecast Error Variance Decomposition is performed using Cholesky factorisation of weights with the ordering sustainable development, industrial output, FDI to provide a dynamic characterisation of the propagation of the shocks. Table 6 and Figure 1 show the results of the sustainable development equation for a time period of ten periods. By period one, the own-shocks share of

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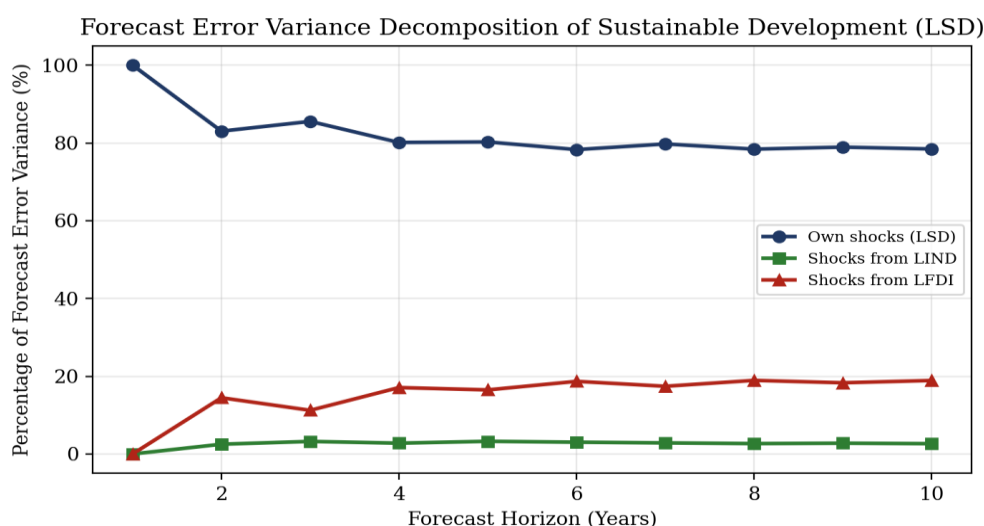
the forecast error variance of sustainable development is 100 per cent, as Cholesky ordering requires, but it drops precipitously to 83.0 per cent by period two, with FDI shocks explaining 14.5 per cent of the forecast error variance and industrial output shocks accounting for the remaining 2.5 per cent. In periods 4 and beyond, the contribution of FDI shocks levels off at around 17-19 per cent, whereas the contribution of industrial output shocks is modest, at around 2.7-3.3 per cent over the horizon. This pattern corroborates the results of Asongu and Nwachukwu (2017) who report that FDI shocks are the major external component driving variability in African development indicators, and it is consistent with the results for Nigeria. It is evident that the role of FDI has been more stable during period four to ten, accounting for 18 to 19 per cent of influence, which suggests that this influence is not temporary. The breakdown of the variance of FDI's own forecast error is noteworthy: FDI's variance accounts for 72.7 per cent of its own forecast error variance in period one, but this fraction declines consistently to 39.7 per cent in period ten, while that of sustainable development rises from 26.9 per cent to 55.1 per cent over the same period. The general trend suggests that in the medium to long term, the factors determining the volatility of FDI inflows move from FDI to sustainable development outcomes, with the latter becoming the more determinant. This suggests that Sustainable development outcomes are not necessarily a one-way street to FDI inflows, but there is a bi-directional and self-reinforcing relationship between the two.

Table 6: Forecast Error Variance Decomposition of Sustainable Development (LSD)

Period	S.E.	% LSD (own)	% LIND	% LFDI
1	0.3486	100.00	0.00	0.00
2	0.4796	83.03	2.51	14.46
3	0.5454	85.54	3.23	11.23
4	0.6020	80.13	2.78	17.08
5	0.6545	80.26	3.26	16.48
6	0.6946	78.29	3.03	18.68
7	0.7316	79.74	2.85	17.41
8	0.7744	78.41	2.67	18.93
9	0.8133	78.93	2.77	18.31
10	0.8469	78.45	2.65	18.90

Cholesky Ordering: LSD, LIND, LFDI. Source: Author's computation using EViews 12 (2026)

Figure 1: Forecast Error Variance Decomposition of Sustainable Development (LSD)



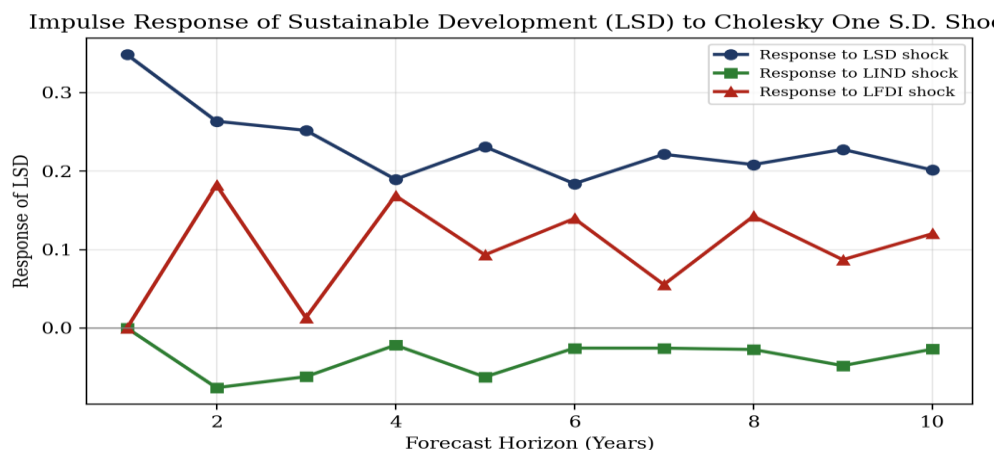
4.2.3 Impulse Response Analysis

Figure 2 and the discussion below report the effects on sustainable development under one standard deviation Cholesky shocks in each variable of the system over ten periods. A shock to sustainable development itself results in a large and persistent positive own response, with the response starting at 0.349 in period one and staying between 0.184 and 0.227 from period four onwards, thus representing a high level of path dependency, consistent with institutional inertia and accumulated human and infrastructure capital (North, 1990; Acemoglu & Robinson, 2012). The response of sustainable development to a shock to industrial output is consistently negative through all the periods, starting at a minimum -0.076 in period two, and a maximum -0.022 in period four, and ranging between -0.025 and -0.048 after that, reflecting the prevailing extractive-dominated character of Nigeria's industrial structure (Adedoyin et al., 2020) with the degradation-dominant side of the Environmental Kuznets Curve. Conversely, a shock to

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FDI yields an oscillating, but generally positive, response in sustainable development, with the response peaking at 0.182 in period two and then settling at 0.013 in period three, recovering to 0.169 in period four, and oscillating between 0.055 and 0.140 over periods 7 through 10 for an average of about 0.107 in the full horizon. This oscillation highlights both positive effects of FDI (like job creation and technology transfer) and negative effects (profit repatriation, and limited backward linkages) (Alfaro, Chanda, Kalemli-Ozcan, & Sayek, 2004; Ayanwale, 2007) and it suggests that the net effect of FDI shocks on sustainable development is positive on average but may need to be managed through policies.

Figure 2: Impulse Response of Sustainable Development (LSD) to Cholesky One S.D. Shocks



The reaction of FDI to shocks in sustainable development is particularly illuminating with regards to the mutual response dynamic pointed out by the variance decomposition results. A positive shock to sustainable development causes a positive response for FDI along the whole horizon, starting at 0.114 in period 1 and the average is around 0.096, without turning negative. This result directly confirms the dynamic effect of better sustainable development performance on FDI inflows in Nigeria, whether it is due to better governance, education, health or environmental management, as previously proposed by the theory by Asiedu (2006) and supported by empirical findings by Colen, Maertens and Swinnen (2009) for Sub-Saharan Africa. When taken together with the evidence on the negative impact of industrial output on sustainable development, cited above, and the positive evidence on the impact of FDI on sustainable development in Nigeria, cited above, this evidence suggests that there is a true feedback loop between the Nigerian FDI-industry-sustainability system and not merely a one-way relationship as suggested by much of the cross-country panel literature reviewed in Section 2.

4.2.4 Post-Estimation Diagnostics

Table 7 provides the summary diagnostic tests applied to test the statistical reliability of the estimated VECM system. The VEC residual heteroskedasticity test provides a joint chi-square of 130.480, with 132 degrees of freedom, and a probability of 0.521 – comfortably failing to reject the null hypothesis of homoskedastic residuals and indicating that the standard errors for the reported coefficients are not distorted by heteroskedasticity. Residual normality tests, similarly based on Cholesky orthogonalisation, also fail to reject the multivariate normality hypothesis: joint skewness = 0.739 (p-value = 0.864); joint kurtosis = 0.621 (p-value = 0.892); joint Jarque-Bera = 1.360 (p-value = 0.968). The first difference lag is statistically insignificant in the lag exclusion Wald test (chi-square = 10.248, p = 0.331), but the second difference lag is only statistically significant for the sustainable development equation (chi-square = 8.798, p = 0.032), which means that it remains in the system. Formal Granger causality test results indicate that there is a unidirectional causality from FDI to sustainable development in the short run (chi-square = 7.689, p = 0.021), but no causality from industrial output to sustainable development, from sustainable development to industrial output or FDI, and from industrial output to FDI in the short run. Together, these diagnostics suggest that the estimated VECM system is well specified and that the coefficient results, error correction dynamics and impulse response results presented above are statistically sound and form the basis for the discussion that follows.

Table 7: Post-Estimation Diagnostic Tests

Test	Statistic	Prob.
VEC Residual Heteroskedasticity (Joint, df=132)	130.480	0.521
Residual Normality: Skewness (Joint, df=3)	0.739	0.864
Residual Normality: Kurtosis (Joint, df=3)	0.621	0.892

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Residual Normality: Jarque-Bera (Joint, df=6)	1.360	0.968
Lag Exclusion Wald, Lag 1 (Joint, df=9)	10.248	0.331
Lag Exclusion Wald, Lag 2, D(LSD) (df=3)	8.798	0.032
Granger Causality: D(LFDI) -> D(LSD) (df=2)	7.689	0.021**
Granger Causality: D(LIND) -> D(LSD) (df=2)	0.103	0.950
Granger Causality: D(LSD) -> D(LIND) (df=2)	2.685	0.261
Granger Causality: D(LSD) -> D(LFDI) (df=2)	2.259	0.323
Granger Causality: D(LIND) -> D(LFDI) (df=2)	2.401	0.301

4.3 DISCUSSION OF FINDINGS

The result of this study has provided a more nuanced picture of the FDI-industrial output-sustainable development nexus in Nigeria which confirms and qualifies expectations based on the theoretical and empirical literature surveyed in Section 2. Interestingly, the cointegration results show that sustainable development, industrial output, FDI and the associated macroeconomic controls are related in a permanent long-run relationship, thus answering the first research question directly and supporting the proposition of the Eclectic Paradigm that FDI, location-specific industrial capacity and more general development outcomes do not stand in isolation as independent phenomena but are instead structurally interlinked (Dunning, 2001). This evidence is in line with the overall literature of cointegration among macro-economic development indicators found for Sub-Saharan Africa (Asongu & Nwachukwu, 2017; Omri et al., 2014), but also adds to the literature the use of a multi-dimensional sustainable development index, instead of a single environmental or growth proxy.

The empirical evidence from the negative long run VECM coefficient of FDI and the negative short run response of sustainable development to industrial output shocks in the impulse response analysis provide support for the Pollution Haven Hypothesis and the left hand side of the Environmental Kuznets Curve in the Nigerian context. This is in line with the results of Bagirzadeh et al. (2025) who found that the positive economic impact of FDI in Lithuania did not translate into significantly lower GHG emissions. Meanwhile, the Granger causality and impulse response results indicate that the relationship is not unidirectional as depicted in much of the literature: shocks in sustainable development are found to have a uniformly positive impact on the subsequent evolution of FDI inflows; and the variance decomposition evidence shows that sustainable development's role in explaining the volatility of FDI inflows increases from 26.9 per cent to 55.1 per cent over a ten-year window. This reciprocal relationship confirms the theoretical argument of Asiedu (2006) and the empirical one of Colen et al. (2009) for Sub-Saharan Africa that the quality of the country's development is actually an investment promotion instrument, and not just a result of investment. This study adds to the empirical work of Osabohien et al. (2025) who detect a positive relationship between global value chain participation and sustainable industrial output, but do not test the effect of sustainable industrial output on FDI attraction, and to the mediation analysis of Xue et al. (2024) who show that the effects of outward FDI on Chinese manufacturing sustainability are mediated by technological progress and openness. Additionally, the rapid error correction speed of 71.3 per cent identified in the present study is more than what is generally reported in similar Nigerian and African studies conducted on VECM (Adedoyin et al., 2020), suggesting that in the past, short-run shocks to the FDI-industry-sustainability system have been disruptive but the Nigerian economy has been able to return to long-run equilibrium in the short run, which is important for the design and sequencing of policy interventions as discussed in Section 5.

Lastly, the significant negative short-run effect of money supply growth on sustainable development and the significant positive short-run effect of exchange rate depreciation, places the FDI-industry-sustainability relationship in its broader Nigerian macro-economic context. These results corroborate those of Abere and Akinbobola (2020) on the role of macroeconomic shocks and institutional quality in economic performance in Nigeria and those of Abere and Ojo (2025) on the impact of exchange rate management on growth outcomes in oil-exporters of Africa, which conclude that the economic benefits of FDI and industrialization in Nigeria cannot be assessed without reference to the overall stability of the macroeconomic environment in which such investment or industrialization occurs.

5. CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This study aimed to examine the dynamic relationship between foreign direct investment, industrial output and sustainable development in Nigeria between 1981 and 2024 with a vector error correction model estimated on a seven variable system comprising of government expenditure, money supply, the exchange rate and inflation as macroeconomic controls. The evidence shows first that these variables have a long run equilibrium relationship that is persistent, as confirmed by the Johansen trace test, with four cointegrating vectors, and as confirmed by the error correction term, which shows that seventy-one per cent of the deviations from the long run equilibrium are corrected within one year. Second, the study shows that the relationship between FDI and sustainable development in Nigeria is not straightforward nor unidirectional, because while FDI has a negative long run VECM coefficient and a negative lagged short run effect on sustainable development, consistent with the environmental and social costs of

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Nigeria's extractive FDI orientation, FDI shocks also produce an oscillating but net positive impulse response in sustainable development, and crucially, sustainable development shocks also generate a sustained positive impulse response in future FDI inflows, with the contribution of sustainable development to the forecast error variance of FDI reaching more than fifty-five per cent after 10 periods. Third, a negative short-run effect of industrial output shocks on sustainable development is consistently observed in line with the left-hand side of the Environmental Kuznets Curve as Nigeria remains a country that is still dependent on resource-intensive industrial activity. Overall, these findings show that foreign direct investment, industrial output and sustainable development are not static and unidirectional, but a dynamic, reciprocal and time-varying nexus, as proposed by this study's title proposition: Foreign direct investment and industrial output, sustainable development are interrelated in a way that can best be understood as a genuinely dynamic system, in which investment in quality sustainable development serves as both a development goal and a means for sustaining productive foreign investment, and the ecological and social costs of extractive-intensive industrialization continue to be a limit on the short-term sustainability dividends of extractive-intensive industrialization.

5.2 RECOMMENDATIONS

The following recommendations are based on the empirical findings. First, the Nigerian Investment Promotion Commission (NIPC) should identify, design and apply a formal Environmental, Social and Governance (ESG) screening framework for inward FDI, which should include screening of investment funds such that the manufacturing and renewable energy, agro-processing and digital-economy sectors could be a priority over further investment in the extractive sector, since it was the sector identified in this study as having negative long run and lagged short run effects. Second, recognizing the existence of a feedback loop between the performance of sustainable development and FDI attraction, there is a need to regard investment in human resources, governance, infrastructure, and environmental management not just as a development goal per se, but as an investment-promotion tool that could help drive more high-quality FDI inflows in the medium to long term. Thirdly, given the substantial negative short run impact of money supply growth on sustainable development, the Central Bank of Nigeria ought to exercise monetary discipline and ensure that monetary expansion is tightly coupled with productivity growth, instead of deficit financing, to minimize the inflationary erosion of household welfare identified in this study which undermines sustainable development outcomes. Fourth, because of the important positive short-term impact of the exchange rate depreciation on sustainable development, exchange rate policy should not aim to maintain the naira at an artificially high level and, instead, be reflective of the market and competitive enough to benefit the tradable and export-oriented sectors where the greatest potential for FDI and industrial activities to lead to more general development gains exists. Fifth, since there is a longstanding negative short-run association between industrial output shocks and sustainable development, industrial policy should be directly connected with environmental regulation and cleaner production incentives, especially in the extractive and heavy manufacturing sub-sectors, to help Nigeria move along the Environmental Kuznets Curve toward a regime where industrial output promotes, rather than detracts from, sustainable development outcomes.

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