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Impact of Foreign Direct Investment on Sustainable Growth in the Nigerian Agricultural Sector (1984–2023)

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Abstract

This study investigates the impact of Foreign Direct Investment (FDI) on sustainable growth in Nigeria's agricultural sector, employing annual time-series data spanning 1984 to 2023. The Autoregressive Distributed Lag (ARDL) model is applied to examine short-run and long-run dynamics between agricultural productivity and four key variables: FDI inflows to agriculture, agricultural employment, agricultural machinery, and CO_2 emissions from agriculture. The ARDL bounds test reveals no evidence of a long-run cointegrating relationship, indicating that FDI has not exerted a statistically significant influence on agricultural productivity over the long term. In the short run, agricultural employment exhibits a significant but negative effect on agricultural output, while FDI inflows, agricultural machinery, and CO_2 emissions are statistically insignificant. Drawing on the absorptive capacity framework of Borensztein, De Gregorio, and Lee (1998), the study argues that Nigeria's agricultural sector lacks the human capital, institutional quality, and technological readiness required to convert FDI inflows into measurable productivity gains. The findings have direct policy relevance: sustainable agricultural growth in Nigeria requires structural reforms that build absorptive capacity rather than simply attracting more foreign capital. HuberWhite heteroskedasticity-consistent standard errors are employed throughout to ensure robust inference.

Keywords: *Foreign Direct Investment, Agricultural Productivity, Sustainable Growth, ARDL Model, Absorptive Capacity, CO_2 Emissions, Agricultural Employment.*

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Introduction

Agriculture remains the cornerstone of Nigeria's economy, contributing substantially to employment, food security, and overall economic growth [1]. The sector accounts for over 20 per cent of GDP and employs more than 60 per cent of the labour force, particularly in rural areas [2]. Yet despite its structural importance, the sector grapples with persistent low productivity driven by outdated farming practices, inadequate infrastructure, limited access to credit, and mounting climate vulnerability [3]. These challenges raise fundamental questions about the long-run ecological sustainability and social equity of Nigeria's agricultural development pathway, with direct implications for progress towards the Sustainable Development Goals [4].

Foreign Direct Investment (FDI) has long been regarded as a potentially transformative force in developing economies, bringing capital, advanced technology, managerial expertise, and access to global markets [5], [6]. In agriculture specifically, FDI holds the promise of enhancing productivity through modern farming techniques, improved value chain efficiency, and the diffusion of sustainable practices [7], [8]. Nigeria has articulated a strategic commitment to attracting agricultural FDI, supported by policy frameworks such as the Agricultural Transformation Agenda and the Agricultural Promotion Policy [9].

However, theoretical and empirical evidence on whether FDI actually delivers these benefits in the Nigerian agricultural context remains deeply contested [10], [11].

The study contributes to the literature by providing sector-specific empirical evidence on this contested question. A growing body of theoretical work most notably the absorptive capacity framework of Borensztein et al. [12] suggests that FDI generates productivity gains only when host-country absorptive capacity exceeds a minimum threshold. Nigeria's predominantly subsistence-based agricultural sector, characterised by low educational attainment among farm workers, weak institutions, and limited technological infrastructure, may not meet this threshold a proposition this study evaluates indirectly through empirical analysis. By employing the ARDL bounds testing approach with annual data from 1984 to 2023, the study generates temporally differentiated evidence on FDI's short-run and long-run effects that is directly relevant to agricultural policy design.

Research Questions

i. What is the nature and direction of the relationship between FDI inflows into the agricultural sector and agricultural productivity in Nigeria?

ii. To what extent do agricultural employment, technological advancement, and environmental impact influence agricultural productivity in Nigeria in both the short run and the long run?

Objectives

i. To ascertain the nature and direction of the relationship between FDI inflows into the agricultural sector and agricultural productivity in Nigeria.

ii. To assess the contribution of agricultural employment, technological advancement, and environmental impact to agricultural productivity in Nigeria in both the short run and the long run.

Hypotheses

H_{01}: There is no statistically significant effect of FDI inflows in agriculture on agricultural productivity in Nigeria.

H_{02}: Agricultural employment, technological advancement, and environmental impact do not exert a statistically significant effect on agricultural productivity in Nigeria in the short run and long run.

Literature Review

Conceptual Literature Review

Foreign Direct Investment (FDI) refers to cross-border investment made by a firm or individual into business interests in another country, typically through acquiring business assets or establishing productive operations [13]. FDI encompasses equity capital, reinvested earnings, and intra-company loans and is regarded as a major source of external financing for developing economies. Dunning's [14] eclectic OLI Paradigm identifies Ownership, Location, and Internalisation advantages as the principal determinants of FDI decisions. In Nigeria, FDI is recognised as a potential catalyst for agricultural modernisation, but the extent to which it generates long-term, inclusive, and environmentally sustainable productivity gains remains an open empirical question [15].

Sustainable Growth as a concept originates from the Brundtland Commission's landmark 1987 Report, which defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs [16]. Sustainable agricultural growth encompasses three mutually reinforcing pillars: economic growth, environmental protection, and social inclusion. Achieving it requires not only increased investment but a fundamental alignment of agricultural practice with long-run environmental and social goals [17]. Within the empirical framework of this study, sustainability is operationalised through selected measurable dimensions: agricultural productivity, employment dynamics, technological capacity, and environmental pressure represented by agricultural CO_2 emissions. This operationalisation reflects data availability and the boundaries of the ARDL framework employed; broader sustainability constructs such as governance, resource depletion, and climate adaptation capacity are acknowledged as important but fall outside the scope of this study. FDI, if properly directed and regulated, can serve as a strategic catalyst in advancing these objectives.

Absorptive Capacity and the FDI-Productivity Nexus. Borensztein, De Gregorio, and Lee [12] establish theoretically and empirically that FDI raises host-country productivity only when the recipient economy possesses a minimum stock of human capital sufficient to absorb and diffuse the technology and knowledge that foreign investors bring. Below this threshold, FDI flows into the host economy without generating meaningful productivity spillovers. This absorptive capacity framework is directly applicable to Nigeria's agricultural sector: with a largely informal, low-skilled farming workforce and weak institutional frameworks for technology extension and diffusion, the sector may systematically fall below the absorption threshold required for FDI to exert a positive productivity effect. This study evaluates this proposition indirectly through empirical analysis.

Theoretical Literature Review

Modernisation Theory, associated with Rostow [18] and Todaro and Smith [19], posits that FDI acts as an agent of transformation, introducing capital, technology, and managerial know-how that can modernise traditional agricultural systems. The theory rests on the assumptions that technology diffuses from investor to host community over time and that the resulting productivity benefits accrue broadly across the rural economy. In the Nigerian context, however, these assumptions have been challenged by evidence of weak technology absorption and limited linkages between foreign agribusinesses and smallholder producers, pointing to the importance of absorptive capacity as a mediating condition.

Endogenous Growth Theory, pioneered by Romer [20] and Lucas [21], argues that long-run growth is driven endogenously by human capital accumulation, innovation, and knowledge spillovers. Applied to FDI, the theory predicts that foreign investment generates positive externalities in the form of knowledge spillovers to local firms and workers but only when the host economy's absorptive capacity is sufficiently developed to capture and diffuse these spillovers. This conditional prediction directly informs this study's interpretation of the finding that FDI does not significantly influence agricultural productivity in Nigeria.

Dependency Theory, advanced by Frank [22], contends that FDI tends to perpetuate economic dependence in peripheral economies by prioritising profit repatriation over local reinvestment and generating enclave investment patterns with limited spillovers to domestic smallholder farming systems.

Ecological Economics Perspective. The ecological economics framework, developed principally by Daly [23] and Costanza et al. [24], holds that the economy is a subsystem of the biosphere and that there are absolute biophysical limits to growth. This perspective provides the conceptual rationale for incorporating CO_2 emissions from agriculture as an explanatory variable in the empirical model, framing the study's concern with whether FDI-driven agricultural growth is genuinely sustainable or whether output gains are being achieved at the cost of ecological capital depletion.

The OLI Paradigm. Dunning's [14] Eclectic Theory integrates Ownership, Location, and Internalisation advantages to explain multinational enterprise investment decisions. Applied to Nigeria's agricultural sector, Location advantages such as arable land and government incentives attract FDI, but developmental benefits depend critically on the strength of the host country's institutional environment.

Empirical Literature Review

The empirical literature on FDI and agricultural growth reveals a consistently mixed and context-dependent picture. For each study, the review identifies the authors and year, primary objective, methodology, principal findings, and recommendations, enabling systematic identification of the gaps this study addresses.

Nyiwul and Koirala [25] reviewed the role of foreign direct investment in agriculture, forestry and fishing across developing countries, finding that while FDI inflows to the agricultural sector can support output growth, the realisation of productivity benefits is highly conditional on complementary domestic investment in infrastructure, human capital, and institutional capacity. The study recommended that host-country governments strengthen the enabling environment for agricultural investment rather than relying solely on FDI attraction policies.

Dhahri and Omri [26] investigated the role of foreign capital in advancing food security targets using a dynamic panel framework covering 50 developing countries over the period 1995 to 2015. They found that FDI directed towards agricultural production generates significant improvements in food availability outcomes and contributes to progress on SDG targets for poverty and hunger reduction. The study recommended that developing-country governments structure foreign capital inflows to prioritise agricultural productivity as a pathway to food security.

Owutuamor and Arene [27] examined the impact of FDI on agricultural growth in Nigeria from 1979 to 2014 using cointegration analysis and OLS estimation. The study found a positive but statistically insignificant relationship between FDI and agricultural growth, concluding that inadequate institutional frameworks and low FDI inflows relative to the sector's contribution to GDP undermine the developmental potential of foreign capital in Nigerian agriculture. Kastratović [28] examined the environmental dimensions of agricultural FDI using panel data from 63 developing countries and found that FDI inflows to agriculture were positively associated with increased greenhouse gas emissions, providing weak support for the pollution haven hypothesis and raising important concerns about the ecological sustainability of FDI-driven agricultural development.

Edeh, Eze and Ugwuanyi [29] investigated the impact of FDI on Nigeria's agricultural sector from 1981 to 2017 and found that while FDI exerted a positive long-run influence on agricultural output, the benefits were concentrated in specific investment segments rather than diffusing broadly across the smallholder farming economy. Dhahri and Omri [30] found that foreign capital's impact on agricultural production in developing countries is highly heterogeneous: positive in some sub-sectors and country contexts but conditional on institutional capacity and the availability of complementary policy environments. Ogbanje and Salami [31] established a long-run cointegrating relationship between FDI and Nigeria's agricultural sector over 1981– 2019, but concluded that the realisation of these long-run benefits depended on stable macroeconomic conditions and complementary public investment in agricultural infrastructure. Sokunbi et al. [32] examined the nexus between FDI and employment in Nigeria's agricultural sector from 1990 to 2021 and found that FDI contributed an insignificant impact on employment generation, with agricultural gross production and government expenditure on agriculture generating unexpected negative employment effects consistent with capital-intensity and structural displacement dynamics.

Olasehinde and Ajayi [33] found that FDI exerted positive and significant short- and long-run impacts on economic growth in Nigeria using the ARDL bounds technique over the period 1981–2020, concluding that stable exchange rate management and complementary macroeconomic conditions are essential enabling conditions for productive FDI. Agba et al. [34] examined the impact of FDI on agricultural output in Nigeria using an error correction modelling approach and found evidence of a long-run relationship between FDI and agricultural output, while noting that productivity gains remained sensitive to macroeconomic conditions across both short-run and long-run horizons.

Gaps in the Literature

The reviewed empirical literature reveals three substantive gaps this study addresses. First, the majority of existing studies examine the aggregate effects of FDI on national GDP without disaggregating by sector [33], [35], leaving the specific dynamics of agricultural FDI poorly understood. Second, sector-level studies concentrate on output outcomes while giving insufficient attention to environmental and social sustainability dimensions such as CO_2 emissions and employment quality [27], [28]. Third, few Nigerian agricultural studies employ the ARDL bounds testing framework capable of simultaneously capturing short-run and long-run dynamics a temporal distinction critical for sound policy design, since FDI effects are known to differ substantially across time horizons [32], [34].

Methodology

Research Design and Theoretical Framework

This study adopts an ex post facto research design using annual time-series secondary data for Nigeria spanning 1984 to 2023 (40 observations). The theoretical framework is the absorptive capacity model of Borensztein et al. [12], which provides the primary analytical lens for interpreting the relationship between FDI and agricultural productivity. The framework predicts that FDI generates positive productivity effects only when host-country absorptive capacity measured by human capital stock, institutional quality, and technological infrastructure exceeds a critical minimum threshold. This prediction is directly testable within the ARDL framework and provides the theoretical basis for anticipating that FDI may not exert a significant productivity effect in Nigeria's predominantly subsistence-based agricultural sector.

Model Specification

The general functional form of the model is:

AGRICOUT = f (FDIAGRIC, EMPAG, CO_2AG, MACH) … (1)

The ARDL specification is estimated with LAGRICOUT and LCO_2AG transformed into natural logarithms to reduce skewness and improve linearity, while FDIAGRIC, EMPAG, and MACH are retained in levels consistent with their measurement units and distribution properties. The specification is:

$$\Delta \ln AGRICOUT(t) = \beta_0 + \sum\beta_1\Delta \ln AGRICOUT(t-i) + \sum\beta_2\Delta FDIAGRIC(t-i) + \sum\beta_3\Delta EMPAG(t-i) + \sum\beta_4\Delta \ln CO_2AG(t-i) + \sum\beta_5\Delta MACH(t-i) + \phi_1 \ln AGRICOUT(t-1) + \phi_2 FDIAGRIC(t-1) + \phi_3 EMPAG(t-1) + \phi_4 \ln CO_2AG(t-1) + \phi_5 MACH(t-1) + \varepsilon t \quad \ldots (2)$$

Where lnAGRICOUT (logged) is the dependent variable (agricultural productivity); FDIAGRIC represents FDI inflows to agriculture (in levels); EMPAG represents agricultural employment (in levels); lnCO_2AG (logged) represents CO_2 emissions from agriculture; MACH (in levels) represents agricultural machinery as a proxy for technological advancement; β_0 is the constant; β_1–β_5 are short-run dynamic coefficients; ϕ_1–ϕ_5 are long-run level coefficients; and εt is the white noise error term. The model is specified as a single equation to avoid endogeneity problems inherent in systems of equations. Data were sourced from the World Development Indicators (WDI) and the Central Bank of Nigeria (CBN) Statistical Bulletin. All estimations were performed using EViews 12.

Variable Measurement and Justification

Agricultural productivity (AGRICOUT) is measured by agricultural value added in constant US dollars the most widely adopted and internationally comparable measure of sector-level output in the empirical literature [25], [33]. FDI inflows to agriculture (FDIAGRIC) are measured in millions of current US dollars as reported in the CBN Statistical Bulletin and WDI, which provide the most granular sector-disaggregated FDI data available for Nigeria. The authors acknowledge, consistent with the limitations of national FDI reporting frameworks, that sector-specific FDI data involve some degree of estimation; however, the CBN–WDI series represents the best available data for this purpose and is the standard source used in the Nigerian empirical literature.

Agricultural machinery (MACH), measured as tractors per 100 square kilometres of arable land, is employed as the proxy for technological advancement, consistent with prior studies in the African agricultural economics literature

[25], [33]. While this measure captures only the mechanisation dimension of agricultural technology, it is the most consistently available and internationally comparable indicator of farm technology adoption for Nigeria over the study period. CO_2 emissions from agriculture (CO_2AG), sourced from the WDI, serve as the environmental impact variable and reflect direct greenhouse gas emissions from agricultural production activities including enteric fermentation, manure management, and burning of agricultural residues.

Pre-Estimation Tests

To guard against spurious regression, the Augmented Dickey-Fuller (ADF) unit root test is applied to all variables. The ARDL bounds testing approach of Pesaran, Shin, and Smith [36] is then employed for cointegration testing. The ARDL approach is selected for three reasons: (i) it accommodates variables of mixed integration orders I(0) and I(1) without requiring all variables to be integrated of the same order; (ii) it simultaneously estimates short-run dynamics and tests for long-run equilibrium relationships; and (iii) the finite sample critical values tabulated by Pesaran et al. [36] are specifically designed for small sample sizes, making the approach well-suited to this study's 40-observation dataset. The bounds test decision rule compares the computed F-statistic against upper and lower critical value bounds: if the F-statistic exceeds the upper bound, a long-run cointegrating relationship is confirmed; if it falls below the lower bound, no long-run relationship exists. Post-estimation diagnostics include serial correlation, heteroskedasticity, normality, and parameter stability tests.

Results and Discussion

Descriptive Statistics

Table 1 presents descriptive statistics for all study variables over the 40-year sample period.

Table 1. Descriptive Statistics of Study Variables

Statistic	AGRICOUT	FDIAGRIC	EMPAG	CO_2AG	MACH
Mean	2017.797	129.670	45.159	0.319	8.583
Median	1914.072	90.240	46.202	0.157	8.260
Maximum	3443.523	481.909	52.397	1.680	14.822
Minimum	985.788	4.345	34.310	0.031	2.726
Std. Dev.	981.991	106.575	5.856	0.386	2.191
Skewness	0.196	1.478	-0.285	2.188	0.007
Kurtosis	1.309	4.759	1.564	7.250	5.339
Jarque-Bera	5.023	19.724	3.979	62.026	9.152
Prob.	0.081	0.000	0.137	0.000	0.010
Obs.	40	40	40	40	40

Source: Researcher's computation using EViews 12.

Agricultural productivity (AGRICOUT) recorded the highest mean (2,017.797) with a standard deviation of 981.991, reflecting significant variation across the 40-year period consistent with Nigeria's structural economic shifts. FDI inflows to agriculture (FDIAGRIC) display a pronounced positive skew (1.478) and leptokurtic distribution (kurtosis = 4.759), consistent with sporadic large-investment years against a background of generally low inflows. AGRICOUT and EMPAG are normally distributed at the five per cent level ($p = 0.081$ and $p = 0.137$ respectively), while CO_2AG

shows extreme positive skew (2.188) and kurtosis (7.250), reflecting the accelerating trend in agricultural emissions towards the end of the sample period.

Unit Root Test Results

Table 2. ADF Unit Root Test Results

Variable	ADF t-stat	5% Critical	P-value	Order	Remark
LAGRICOUT	-5.3256	-3.5331	0.0005	I(1)	Stationary
FDIAGRIC	-5.0630	-3.5331	0.0011	I(1)	Stationary
EMPAG	-5.1814	-3.5331	0.0008	I(1)	Stationary
LCO_2AG	-3.6025	-3.5298	0.0426	I(0)	Stationary
MACH	-6.0607	-3.5331	0.0001	I(0)	Stationary

Source: Author's computation using EViews 12.

The results reveal a mixed integration order: LAGRICOUT, FDIAGRIC, and EMPAG are integrated of order one [I(1)], becoming stationary upon first differencing, while LCO_2AG and MACH are stationary at levels [I(0)]. This mixed order directly satisfies the conditions for applying the ARDL bounds testing approach, which unlike the Johansen cointegration procedure does not require all variables to be integrated of the same order.

ARDL Model Estimation Results

The AIC-selected model is ARDL(1, 0, 1, 0, 0) from 2,500 evaluated candidate specifications. Table 3 presents the full estimation results, reported with Huber-White-Hinkley (HC1) heteroskedasticity-consistent standard errors and covariance throughout, ensuring that coefficient estimates and their associated standard errors are robust to any residual distributional violations.

Table 3. ARDL Model Estimation Results ARDL(1,0,1,0,0)

Variable	Coefficient	HC1 Std. Error	t-Statistic	Prob.
LAGRICOUT(-1)	0.7960	0.2516	3.1633	0.0035
FDIAGRIC	0.0001	6.87E-05	1.6074	0.1181
EMPAG	-0.0594	0.0101	-5.9022	0.0000
EMPAG(-1)	0.0403	0.0155	2.6063	0.0139
LCO_2AG	-0.0465	0.0315	-1.4773	0.1497
MACH	0.0019	0.0028	0.6698	0.5079
C	2.2433	2.6172	0.8571	0.3979
@TREND	0.0022	0.0042	0.5180	0.6081
R^2	0.9840	Adj. R^2	0.9803	F = 271.53 (p=0.000)

Source: Author's computation using EViews 12. HC1 heteroskedasticity-consistent standard errors applied throughout.

The model exhibits high explanatory power, with R^2 of 0.984 and adjusted R^2 of 0.980, accounting for approximately 98 per cent of the variation in agricultural output. The high explanatory power partly reflects the inclusion of lagged dependent variables and deterministic trend effects commonly observed in ARDL models estimated with trending macroeconomic time series; caution is therefore warranted in attributing this explanatory power exclusively to the regressors rather than to timetrending dynamics in the data. The F-statistic (271.53, p = 0.000) confirms the joint significance of all regressors. HC1 robust standard errors correct for any heteroskedasticity in the error structure, ensuring valid inference throughout.

Short-Run Dynamics

Table 4. Short-Run ARDL Coefficients and Interpretation

Variable	Coefficient	P-Value	Interpretation
LAGRICOUT(-1)	0.796	0.0035	Positive and significant. Strong output persistence: past productivity strongly predicts current output.
FDIAGRIC	0.000	0.118	Statistically insignificant. FDI has no measurable short-run effect on agricultural productivity.
EMPAG	-0.059	0.000	Significant and negative. A 1% increase in agricultural employment is associated with a 0.059% decrease in output, consistent with labour inefficiency and disguised unemployment.
EMPAG(-1)	0.040	0.014	Positive and significant. Employment gains generate modest positive output effects with a one-period lag, reflecting the time needed to productively integrate additional farm labour.
LCO_2AG	-0.046	0.150	Statistically insignificant. CO_2 emissions have no detectable short-run impact on agricultural output.
MACH	0.002	0.508	Statistically insignificant. Machinery use has no measurable short-run productivity effect.

Source: Author's computation using EViews 12.

The most important short-run finding is the strong output persistence captured by the lagged dependent variable (0.796, p =
0.004), reflecting the structural inertia of agrarian systems where production patterns and institutional arrangements change only incrementally. The significant negative effect of agricultural employment (-0.059, p = 0.000) is diagnostically revealing: rather than a genuine negative productivity effect, it is most plausibly explained by the pervasive underemployment and disguised unemployment characteristic of Nigeria's subsistence-based smallholder farming system, where adding labour to fixed plots under low-technology conditions reduces average productivity rather than raising aggregate output consistent with the Lewis [37] characterisation of traditional-sector surplus labour. The positive and significant lagged employment coefficient (0.040, p = 0.014) indicates that these effects are not uniformly negative: with a one-period lag, employment gains generate modest positive output effects, plausibly reflecting seasonal production cycles.

FDI inflows (p = 0.118), CO_2 emissions (p = 0.150), and machinery (p = 0.508) are all statistically insignificant in the short run. The absence of a significant FDI effect on agricultural productivity is interpreted within the absorptive capacity framework: Nigeria's agricultural sector lacks the human capital depth, institutional quality, and technological infrastructure needed to convert FDI inflows into measurable productivity gains. This finding aligns with Borensztein et al. [12], who demonstrate that below the absorptive capacity threshold, additional FDI flows into an economy without generating productivity spillovers. This interpretation is substantiated by independently documented evidence of Nigeria's absorptive capacity deficit. The World Bank's Human Capital Index placed Nigeria at 0.36 in 2020, ranking 168th out of 174 countries, indicating that a child born in Nigeria today can expect to attain only 36 percent of the productivity potential achievable under full health and complete education [39]. Nigeria's public agricultural spending remained at just 2 percent of federal expenditure between 2015 and 2021 far below the 10 percent commitment of the 2003 Maputo Declaration constraining the extension services, institutional capacity, and technological infrastructure that are prerequisite conditions for FDI spill overs to materialise [40]. Over 70 percent of Nigeria's agricultural workforce operates at a subsistence level with limited access to technology, improved inputs, or market linkages [41], precisely the conditions under which absorptive capacity theory predicts FDI will fail to generate measurable productivity effects. The null result of this study is therefore not merely consistent with absorptive capacity theory: it is consistent with Nigeria's measurably low position on the human capital and institutional quality dimensions that theory identifies as necessary for FDI to be productive. The insignificance of the machinery variable despite its availability suggests that the bottleneck is not mechanisation per se but the complementary skills, maintenance capacity, and extension support systems needed to deploy machinery productively.

ARDL Bounds Test for Cointegration

Table 5. ARDL Bounds Test Results

Test Statistic	Value	10% I(0)/I(1)	5% I(0)/I(1)	1% I(0)/I(1)
F-statistic (Asymptotic, n=1000)	0.8949	3.03 / 4.06	3.47 / 4.57	4.40 / 5.72
F-statistic (Finite sample, n=40)	0.8949	3.334 / 4.438	3.958 / 5.226	5.376 / 7.092
t-statistic	-1.5487	-3.13 / -4.04	-3.41 / -4.36	-3.96 / -4.96

Source: Author's computation using EViews 12. Critical values from Pesaran, Shin, and Smith [36].

The F-statistic (0.895) falls substantially below the lower critical value bound at all significance levels under both the asymptotic (n = 1,000) and finite sample (n = 40) critical values. The t-statistic (-1.549) similarly does not breach its lower bound. These results strongly support the null hypothesis of no long-run levels relationship: there is no evidence of cointegration between agricultural productivity and its determinants over the study period. Accordingly, long-run coefficient estimates are not interpreted, consistent with standard ARDL best practice [36]. Analysis is therefore restricted to the short-run dynamics documented above.

Post-Estimation Diagnostic Tests

The Breusch-Godfrey Serial Correlation LM Test yields an F-statistic of 0.797 (p = 0.506) and an Obs*R^2 of 3.069 (p = 0.381), both failing to reject the null hypothesis of no serial correlation at any conventional significance level. The Breusch-PaganGodfrey heteroskedasticity test produces an F-statistic of 1.003 (p = 0.448), confirming that residuals are homoscedastic. The CUSUM and CUSUM of Squares tests confirm that the model's parameters remain stable throughout the 1985–2023 sample period, with both test statistics remaining within the five per cent critical bounds.

The Jarque-Bera normality test yields a statistic of 600.937 (p = 0.000), driven by influential observations associated with major macroeconomic discontinuities the 2016 recession and the COVID-19 shock which generate extreme values in the residual distribution. This does not invalidate the inferential conclusions: HC1 heteroskedasticity-consistent standard errors provide valid inference under non-normality [38], and the asymptotic theory underlying ARDL estimation does not require normally distributed residuals, provided the model is correctly specified [36]. The mean of the residuals is effectively zero (2.30e-16), consistent with correct model specification. The absence of formal structural-break modelling such as ZivotAndrews or Bai-Perron tests is acknowledged as a limitation addressed in Section D below.

Granger Causality Test

Granger causality tests conducted within a bivariate VAR framework reveal no statistically significant short-run predictive relationships among the study's variables. There is no evidence that FDI in agriculture (FDIAGRIC) Granger-causes agricultural output ($p = 0.657$), or vice versa. CO_2 emissions, agricultural machinery, and agricultural employment similarly show no Granger-causal relationships with output. The only noteworthy finding is a marginally significant chi-square statistic for EMPAG Granger-causing FDIAGRIC ($p = 0.057$), providing weak evidence at the ten per cent level that changes in agricultural employment may have short-run predictive power for FDI inflows. These findings are consistent with the absence of long-run cointegration documented in the bounds test, and with the absorptive capacity interpretation: if FDI does not generate measurable productivity effects, the absence of Granger causality between FDI and agricultural output is an expected rather than puzzling result.

Evaluation of Hypotheses

Hypothesis 1 (H_{01}): The coefficient on FDIAGRIC is statistically insignificant in both the short-run estimation ($p = 0.118$) and in the Granger causality tests ($p = 0.657$). The bounds test F-statistic (0.895) falls well below the lower critical bound, confirming the absence of a long-run cointegrating relationship between FDI and agricultural productivity. H_{01} is therefore not rejected. This null finding is substantively interpreted within the absorptive capacity framework: Nigeria's agricultural sector does not currently possess the human capital, institutional quality, and technological infrastructure required to convert FDI inflows into measurable productivity gains.

Hypothesis 2 (H_{02}): The evidence is mixed. Agricultural employment (EMPAG) has a significant negative short-run effect on productivity ($p = 0.000$), warranting partial rejection of H_{02} for employment in the short run. Technological advancement (MACH, $p = 0.508$) and environmental impact (CO_2AG, $p = 0.150$) are both statistically insignificant, and no long-run cointegrating relationship exists for any variable. H_{02} is upheld for technological advancement and environmental impact across all time horizons.

Conclusion and Recommendations

Summary of Findings

This study empirically investigated the impact of FDI on sustainable growth in Nigeria's agricultural sector from 1984 to 2023 using the ARDL bounds testing approach. The major findings are:

(i) No long-run cointegrating relationship exists between FDI inflows to agriculture and agricultural productivity. FDI did not exert a measurable short-run or long-run impact on agricultural output during the study period.

(ii) Agricultural employment has a significant negative short-run effect on productivity (-0.059, $p = 0.000$), consistent with widespread underemployment and diminishing returns to labour in Nigeria's subsistence-dominated farming system. A delayed positive effect materialises after one period (0.040, p = 0.014), reflecting the time needed to productively integrate additional farm labour.

(iii) Technological advancement (machinery) exerts no significant short-run or long-run effect on productivity, suggesting that mechanisation alone is insufficient without the complementary skills, extension services, and maintenance infrastructure needed to deploy it productively.

(iv) CO_2 emissions from agriculture are statistically insignificant across all time horizons, possibly reflecting the cumulative and lagged nature of environmental degradation: the adverse effects of rising agricultural emissions on soil quality and climaterelated stressors may not yet be sufficiently severe to manifest as measurable productivity losses within the 40-year sample period.

Conclusion

This study makes two principal contributions. Empirically, it provides sector-specific evidence that FDI has not contributed meaningfully to agricultural productivity growth in Nigeria over four decades a null finding that is itself informative and that challenges the policy assumption that attracting more FDI automatically delivers sectoral productivity gains. Theoretically, the findings are consistent with the absorptive capacity framework of Borensztein et al. [12]: Nigeria's agricultural sector, characterised by a predominantly informal, low-skilled workforce, weak institutional frameworks, and limited technological infrastructure, appears to fall below the absorptive capacity threshold required for FDI to generate positive productivity spillovers. This reframes the policy question from 'how do we attract more FDI?' to 'how do we build the absorptive capacity needed for FDI to be productive?' a distinction with important implications for agricultural development strategy in Nigeria. It should be noted that the sustainability dimensions examined here productivity, employment, emissions, and mechanisation represent selected empirical proxies; the study does not claim to fully capture sustainable agricultural growth in its broader conceptual form.

Policy Recommendations

i. Build agricultural absorptive capacity as a precondition for effective FDI. Government should invest in agricultural education, vocational training, and extension services to raise the human capital stock of the agricultural workforce. Without this foundation, additional FDI inflows are unlikely to generate the productivity spillovers that theory predicts.

ii. Reorient FDI policy towards quality over quantity. Investment promotion frameworks should prioritise FDI that generates backward linkages with domestic smallholder producers, promotes active technology transfer, and is embedded in local production systems. Fiscal incentives should be conditional on verifiable development outcomes rather than on investment volume alone.

iii. Address labour inefficiency through structural reform. The significant negative short-run effect of employment signals underemployment and disguised unemployment. Government should promote labour-saving technologies for smallholders, strengthen skills development programmes, and create pathways from subsistence farming to more productive agro-processing activities.

iv. Mainstream environmental safeguards in agricultural investment frameworks. Although CO_2 emissions are currently insignificant, their upward trend warrants proactive policy. Environmental impact assessments should be mandatory for large-scale agricultural FDI projects, and climate-resilient farming practices actively promoted.

Limitations and Suggestions for Further Research

This study acknowledges several limitations. First, the measurement of sector-specific FDI inflows involves estimation by statistical agencies and may contain some imprecision. Second, the use of tractors per 100 km^2 as a proxy for technological advancement captures only the mechanisation dimension of agricultural technology; future research could incorporate fertiliser use, improved seed adoption, or digital agricultural technology indices to provide a richer measurement of technological progress. Third, the 40-observation sample, while adequate for the ARDL framework, limits the precision of some estimates. Future research could extend the analysis using more granular sub-sector or state-level data, or apply threshold regression techniques to test the absorptive capacity hypothesis directly by identifying the specific human capital or institutional threshold below which FDI fails to generate productivity effects. Fourth, although the absorptive capacity framework provides the primary interpretive lens for the findings, the study does not directly operationalise absorptive capacity through variables such as education levels, institutional quality indices, extension service infrastructure, or governance indicators. The insignificant FDI coefficients are interpreted through this theoretical lens rather than through direct empirical testing of absorptive capacity conditions; future research incorporating interaction terms or threshold models could more formally test this hypothesis. Fifth, the study does not explicitly model structural breaks associated with major macroeconomic disruptions in the sample period most notably the 2016 economic recession and the COVID-19 pandemic shock of 2020 which may partly explain the residual non-normality observed in the Jarque-Bera test and the concentration of influential observations in the right tail of the residual distribution. Formal structural break tests such as Zivot-Andrews or Bai-Perron, or the inclusion of impulse dummy variables for these episodes, represent a productive avenue for future methodological refinement. Sixth, the sustainability dimensions examined in this study agricultural productivity, CO_2 emissions, employment, and technological capacity represent selected sustainability proxies rather than a comprehensive operationalisation of sustainable agricultural growth; constructs such as resource depletion, biodiversity, climate adaptation capacity, and governance quality fall outside the scope of the present empirical framework. Finally, the high R^2 of 0.984, while explained by the inclusion of lagged dependent variables and deterministic trend effects characteristic of ARDL models estimated with trending macroeconomic series, means that some caution is warranted in attributing explanatory power exclusively to the included regressors rather than to time-trending dynamics in the data.

Data Availability

The annual time-series data (1984–2023) used for the ARDL analysis in this study are obtained from publicly available sources. Agricultural productivity, CO_2 emissions from agriculture, agricultural employment, and agricultural machinery data were sourced from the World Bank World Development Indicators (WDI) database, freely accessible at https://databank.worldbank.org/source/world-development-indicators. FDI inflows to the agricultural sector were sourced from the Central Bank of Nigeria (CBN) Statistical Bulletin, available at https://www.cbn.gov.ng/documents/Statbulletin.asp. All data used in the estimation are annual time-series observations for Nigeria spanning 1984 to 2023. No primary data were collected. All estimation was conducted using

EViews 12; the authors confirm that the dataset and estimation outputs are available upon reasonable request to the corresponding author.

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