Foreign Investment, International Trade and Environmental Sustainability: Exploring Ecological Footprints in 37 African Countries

Forthcoming: Environmental Processes

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Abstract

This study complements existing literature by examining the short-run heterogeneous and long-run homogeneous impacts of foreign direct investment (FDI) and international trade on ecological footprints in 37 African countries for the period 1990 to 2019. Utilizing the pooled mean group estimator, our findings show considerable heterogeneity in the impact of FDI and international trade on ecological footprints in the short run. In particular, the findings revealed that while FDI increases ecological footprints in Botswana, Egypt, and Mauritania, it reduces ecological footprints in Algeria, Comoros, Gambia, and Togo. Furthermore, the findings revealed that international trade increases ecological footprints in Cameroon, Cote d'Ivoire, and Eswatini but reduces ecological footprints in Algeria, Mauritania, and Morocco. Nonetheless, the study finds that in the long run, FDI significantly reduces ecological footprints while international trade has no significant influence on the environment. The study further finds economic growth and population to be significant in propping up ecological footprints in the long run. Policy recommendations based on these findings are discussed.

Keywords: Foreign Direct Investment, International Trade; Environmental Sustainability; Ecological Footprints; Pooled Mean Group.

JEL Classification: C33; F18; F21

1. Introduction

The flow of foreign direct investment (FDI) and international trade between world economies stands as one of the upsides of globalization (World Bank 2019, 2021; IMF 2020). They are typically followed by several economic benefits, such as technological transfers, human capital enhancement, job creation, economic productivity and capital investment (Mamingi and Martin 2018; Sabir et al. 2019; Fite 2020). Interestingly, recent studies including Asamoah, Mensah and Bondzie (2019); Ghazouani (2021); Liu et al. (2021); Xu et al. (2021); Nepal et al. (2021); Kisswani and Zaitouni (2021); Qamruzzaman (2021) and Rakshit (2021) have provided evidence on the role of international trade and foreign direct investment (FDI) in stimulating environmental sustainability in both developed and developing economies. However, their efforts have been met with diverse outcomes, with some empirical findings showing that international trade and FDI are good for the environment while others show a negative association.

Africa's level of environmental sustainability when compared to other regions of the world is low, and with growing globalization levels and economic activities, the ability for the region to curtail environmental degradation is put into question. On the one hand, the pollution haven hypothesis reveals a negative environmental performance impact of FDI due to less stringent environmental regulations (Ridzuan, Ismail and Hamat 2017, 2018; Joshua, Bekun and Sarkodie 2020). On the other hand, the pollution halo hypotheses argue for the positive effects of FDI. A perusal of literature such as Ridzuan, Ismail and Hamat (2018), Ayamba et al. (2020), Ahmad et al. (2020) emphasizes that the presence of foreign subsidiaries would lead to a decrease in environmental deterioration through adoption of cleaner energy.

The impact of international trade on environmental qualities has been widely discussed (Ridzuan et al. 2018; Ling, Ab-Rahim and Mohd-Kamal 2020; Ali et al. 2021; Ma, Murshed and Khan 2021). Over the past decades, the level of international trade statistics has been on the rise, not least because according to a World Bank (WB) 2020 report, the corresponding contribution of international trade has significantly increased from 27.3% in 1970 to 60.3% of gross domestic product (GDP) in 2019. Furthermore, by 2021 global trade reached $28.5 trillion, representing an improvement of 25% in 2020 and 13% higher compared to 2019, prior to the advent of the COVID-19 pandemic (World Bank 2022). Moreover, over the past six decades, the pace of trade activity has expanded at a faster rate compared to the first period of globalization.

According to Bernard and Mandal (2016); Khan, Weiliand and Khan (2022), most trade activities have been at the expense of the natural environment. Studies by Ogbuabor (2017), Longe et al. (2020), Nathaniel et al. (2021) have identified trade activities such as importation of technologies, oil products, intensive agricultural system and industrialization (chemical industries), health status, transport services, and education as increasing factors for environmental degradation. This nexus between trade and sustainable development concerns has led several authors to consider that increased international trade might lead to a race to the bottom with regard to social and environmental protection (Potoski and Prakash 2005; Morin, Dürand Lechner 2018; Mosley andSinger 2015; Murshed 2020). Nonetheless, international trade can see the rise in importation of renewables which are more environmentally friendly than non-renewable energy and thus improve the quality of the environment. This line of thought is supported by the pollution halo hypothesis. As conceived in this study, the concept of environmental sustainability revolves around actions geared towards minimizing the negative impact of increasing human activities on the natural environment. This helps to ensure that the present human activities do not jeopardize the quality of the natural environment in the nearest future.

While literature has explored the trade-environment nexus (Siebert 2011; Destekand Sinha 2020; Nathaniel and Khan 2020; Iheonu et al. 2020, 2021), as well as the FDI-environment nexus (Shahbaz, Nasir andRoubaud 2018; Sabir, Qayyum and Majeed 2020; Iheonu et al. 2021; KisswaniandZaitouni 2021), specific studies on the heterogeneity effect for African region are largely missing. In particular, short-run heterogeneity on the impact of international trade and FDI on environmental sustainability is inevitable. This is because of country-specific characteristics and thus, this has implications in the attainment of the United Nations' sustainable development goals (SDGs) and Africa's Agenda 2063. This study utilizes the Pooled Mean Group (PMG) estimation procedure which accounts for short run heterogeneity but constrains the long run relationship to be homogeneous so long as the long-run homogeneity assumption is true. PMG has the advantage of taking into the modelling exercise combinations of variables which are stationary in levels and after first differencing. Our results show significant heterogeneity on the impact of

FDI and international trade on environmental sustainability in the short-run, using ecological footprints as the indicator for the environment. However, the results show that FDI increases environmental degradation while no significant relationship exist between international trade and the environment in the long run.

The remainder of the paper is structured as follows. Section 2 provides a review of the relevant literature and discusses the connection between international trade, foreign direct investment and environmental sustainability. Section 3 is the theoretical framework, data and methodology. Section 4 is the presentation and analysis of result while section 5 concludes the study.

2. Literature Review

2.1 Linking FDI and Environmental Sustainability

Increasing demand for quality environment has been evident in the influx of studies on environmental sustainability. A considerable number of studies have found links between FDI and environmental performances. For instance, in Bangladesh, Begum (2020) adopted Vector Error Correction Model (VECM) to confirm that FDI inflows have positive impacts on sustainable environmental development. However, they admitted that FDI inflows could cause irreversible damage to the environment and hinder sustainable development and social wellbeing, if environmental concerns are not taken seriously. Applying meta-analysis of 121 estimates, Wei, Ding and Konwar (2022) uphold the view that FDI engenders improved environmental performance via a pollution abatement impact, but not through improvements in green total factor productivity (TFP). With the application of Ordered Probit model (OPM) for 44 African countries. Aust, Morais and Pinto (2020) confirmed the evidence of a positive influence of FDI on the SDGs through basic infrastructure in the region. In Turkey, Şentürk and Kuyun (2021) used VECM causality to analyze the relationship between FDI and sustainable development between 1990-2018. They confirmed a cointegration relationship between FDI and environmental performances.

Supporting the Hallo hypothesis theory with ARDL Bound Testing approach, Maji and Habibullaha (2015) found that FDI inflows positively contribute to reduction of CO_2 emissions. Odugbesan et al. (2020) confirm a unidirectional causality from FDI towards resource rents and sustainable development in a panel of 33 Sub-Saharan African (SSA) countries between 2004–2018. In Singapore, Ridzuan, Ismail and Hamat (2017) revealed that FDI inflows lead to both higher economic growth and better environmental quality between 1970 to 2013. Sabir, Qayyum and Majeed (2020) reveal that FDI has a positive and statistically significant impact on the degradation of the environment in South Asian countries. Shahbaz, Nasir and Roubaud (2018) found that FDI has a positive impact on the French carbon emissions. Their findings further validate the environmental Kuznets Curve (EKC).Ridzuan, Ismail and Hamat (2018) adoption of ARDL estimation revealed that FDI inflows have successfully led to lower pollution levels in Malaysia. Jiang, Zhou, Bai and Zhou (2018) employ a city-level data set of 150 Chinese cities in 2014, to confirm evidence of pollution halo hypothesis, where FDI is negatively related to air pollution. Through Augmented Mean Group (AMG) estimators. Ali et al. (2022) confirmed that FDI has a significant and positive impact on the CO_2 emissions of BRICS (Brazil, Russia, India, China and South Africa) economies.

Incorporating the role of urbanization, and coal consumption on environmental degradation in South Africa. Joshua, Bekun and Sarkodie (2020) adopted ARDL methodology to confirm the existence of a long-run equilibrium relationship between FDI and environmental performance. Their findings reveal that 0.77% and 0.86% of carbon dioxide emissions in the short-run and long-run, respectively, are caused by coal consumption and that FDI is not a driver of economic advancement. In the Chinese provinces between 1997–2015. Wang et al. (2020) reveal a unidirectional causality flowing from CO_2 emissions to GDP per capita in western provinces of China. They conclude on the importance of the implementation of strict laws and regulations for circular economy and sustainable development. Chai et al. (2021) reveals that FDI significantly inhibits the improvement of Global Trade Finance Program (GTFP) in China. Gökmenoğlu, and Taspinar (2016) suggested that FDI, energy consumption, and CO_2 emissions have causal relationships that are bidirectional. Moreover, their findings validated the pollution haven hypothesis and the EKC in Turkey between 1974–2010.

By applying the Driscoll-Kraay standard error pooled ordinary least square method, Ahmad et al. (2020) reveals that FDI improves environmental quality by decreasing CO_2 emissions in a panel of 90 belt and road countries from 1990 to 2017. Ali et al. (2020) adopted Dynamic Common Correlated Effects (DCCE) approach to support a positive relationship between FDI and ecological footprint in the Organization of Islamic Cooperation (OIC) countries. Bekun, Alolaand Sarkodie (2019) combined both Panel Pooled Mean Group-Autoregressive Auto regressive distributive lag model (PMG-ARDL) technique for a panel analysis spanning between 1996–2014 for selected EU-16 countries. The study reveals that overdependence on natural resource rents affects environmental sustainability. Due to increasing carbon pollution, Xie, Wang and Cong (2020) adopted the panel smooth transition regression (PSTR) model to examine the spillover effect of FDI on CO_2 emissions in emerging countries. The results manifest that FDI can directly result in an ascent in CO_2 concentrations. Conversely, between, 1991 to 2014, Xu and Li (2021) found that FDI has a significant negative impact on improved green productivity (IGP) in the BRICS countries. With Pooled Mean Group estimation along with validity tests, Pham et al. (2020) showed that in the long run, CO_2 emission is affected by FDI, GDP per capita, and renewable energy consumption. They further revealed the existence of long-run EKC with N-sharped.

The generalized method of moments (GMM) was used by Farooq et al. (2020) to evaluate the influence of FDI and globalization on environmental quality in OIC economies from 1991 to 2017. From their findings, FDI has a negative influence on environmental quality across the Organization of Islamic Cooperation. Khaskheli et al. (2021) used a panel smooth transition regression (PSTR) model between 1990 and 2016 to study the nonlinear connection between financial development and CO2 emissions. FDI, according to the study, has the potential to reduce CO2 emissions after it has increased above a particular level. Asghari (2013) used fixed and random factors to test the validity of the pollution haven and pollution halo hypotheses and found that FDI did really improve environmental quality in the Middle East and North Africa (MENA) area.

2.2 Linking International Trade and Environmental Sustainability

Informing on the link between international trade and environmental performance, Ertugrul et al. (2016) confirmed that trade openness has positive effect on carbon emissions in Turkey, India, China and Indonesia, whereas in Korea, Thailand and Brazil, trade openness has no significant impact on environment. Longe et al. (2020) articulate that trade and economic growth mitigate environmental degradation while energy consumption increases environmental degradation. Kim et al. (2018) examines the effect of trade on environmental degradation using data from 131 developing economies. They confirm that for the industrialized nations, a positive and beneficial relationship exist between trade flow and economic growth. For the developing economies, a negative relationship between trade flow and environment was found for Estonia, Turkmenistan, Uzbekistan, Armenia, Kyrgyzstan, Latvia, and Russia. In Pakistan, Shahzad et al. (2017) realized that trade openness contributes significantly to the increase in carbon emissions.

Kongkuah, Yao and Yilanci (2022) tested the basic EKC model using the fully modified ordinary least squares (FMOLS), the forecast error variance decomposition (FEVD) and vector error correction model (VECM) analyses. The study found that trade significantly increases CO_2 emissions and the EKC is not valid in China. Boutabba et al. (2018) found that in 17 Sub-Saharan African countries, trade in intermediate goods has a positive long run impact on carbon emissions, whereas, there is a unidirectional causality running from trade in intermediate goods to carbon emissions in the short-run. Hasano et al (2018) in a study of nine oil exporting countries noticed that trade does not engender a significant impact on territory-based carbon emissions, however, a significance influence on consumption-based carbon emissions is apparent in both the short-run and long-run.

Khan, Weili and Khan (2022) employed OLS fixed effects and generalized method of moments regressions to examine linkages between innovation, trade openness and quality institutions in environmental sustainability in a sample of 176 countries. The finding reveals that trade openness, FDI and renewable energy consumption are negatively linked with carbon emission, while most of institutional quality indicators contribute to environmental sustainability significantly. Moreover, they confirm the existence of environmental Kuznets curve hypothesis and pollution halo hypothesis. In Italy, Ali and Kirikkaleli (2022) adopted nonlinear autoregressive distributed lag (NARDL) to examine the asymmetric effect of import on consumption-based CO_2 emissions. They found that rising import is linked with declining consumption-based environmental quality. Wang and Song (2022) confirm that international trade is important for carbon emission reduction and economic development in general. With Pooled Ordinary Least Squares (POLS) and Two-Step System Generalized Method of Moments (SGMM) on six components of trade facilitation, Ibrahim and Ajide (2022) reveal a significant negative nexus between environmental pollution and trade facilitation.

In a panel of 85 countries between 1990-2011, Akin (2014) confirms a positive relationship between CO_2 emissions and energy consumption, trade openness and per capita income using cross-sectional augmented autoregressive distributed lag (CS-ARDL) model, common correlated effects mean group estimators (CCEMG) and augmented mean group (AMG) in the eleven fastest emerging economies. Weimin et al. (2022) applied panel Dynamic least squares (PD-LS) and fully modified ordinary least squares (PFM-LS) approaches to confirm that the impact GDP growth is unfavorable to CO_2. Wang et al. (2022) used integrates multi-regional input-output (MRIO) to confirm that trade has increased the CO_2, NO_2 and SO_2 and emissions of developing economies by 12.9%,12.3% and 9.8%, as well as reduced that of developed economies by 6.0%, 21.2% and 29.4%, respectively. In a study for South Asian Economies between 2000–2018, Ahmed et al. (2022) applied dynamic least square (DOLS) and fully modified least square (FMOLS) to show that the production of clean energy, green trade and green innovation positively contributes to economic growth that is environmentally-friendly. In Germany, Li et al. (2022) confirms that participation in international trade contributed to carbon reduction in developing countries, particularly China and Russia.

Appiah et al. (2022) reveal that a unit rise in imports, industrialization and energy usage and led to an upsurge in emissions by 0.471%, 1.176% and 0.596% during the period 1971-2013, employing Driscoll-Kraay error's regression in pooled OLS. Fatima et al. (2022) in the Gulf Cooperation Council countries between 1990 to 2019 used fully modified OLS models to confirm the existence of a significant negative nexus between export diversification and renewable energy; signifying that renewable energy will be reduced by diversification of products. The empirical findings also showed the presence of Kuznets's hypothesis between export product diversification, non-renewable and renewable energy consumption. Azam et al. (2022) confirm that urbanization, international trade, industrialization, and energy use improves environmental pollution, whereas income engenders an opposite effect.

This section has presented a plethora of study on the relationship between FDI and the environment, as well as international trade on the environment. The findings show considerable difference based on estimation and region of analysis. However, none of these studies took into consideration distinct short run and long run effects, particularly for a large African sample, which is the value addition of this study.

3. Theoretical Framework, Data and Methodology

3.1 Theoretical Framework and Data

The study follows the framework of the stochastic impacts by regression on population, affluence, and technology (STIRPAT) proposed by York et al. (2003). The STIRPAT model reveals that environmental degradation is a function of both demographic and economic factors. The equation of the STIRPAT model is given as:

$$I_{i,t} = \alpha_0 P_{i,t}^{a_1} A_{i,t}^{a_2} T_{i,t}^{a_3} u_{i,t} \quad (1)$$

Equation (1) can be converted to its natural logarithm form given as:

$$lnI_{i,t} = \alpha_0 + a_1 lnP_{i,t} + a_2 lnA_{i,t} + a_3 lnT_{i,t} + u_{i,t} \quad (2)$$

here, $I_{i,t}$ is our environmental degradation indicator. $P_{i,t}$ is population, $A_{i,t}$ is GDP which captures affluence and $T_{i,t}$ is represented by FDI and international trade, ln represents natural logarithm. This study follows Bello et al. (2018) and Iheonu et al. (2021) in their argument that $T_{i,t}$ can be broken down into various variables. In this study, FDI and international trade is substituted for technology since FDI, and trade can transfer technological innovation through diffusion from developed countries to developing countries. Technological innovation can assist in reducing energy pollutants and boost economic activities. It should however be noted that FDI and international trade can also have a negative impact because of dumping activities from countries which see developing countries as pollution haven.

The dependent variable of the study is ecological footprint which is utilized to capture environmental sustainability and have been adopted by the Eregha, Nathaniel and Vo (2022) and Nathaniel, Anyanwu and Shah (2020). Ecological footprint measures the ecological asset that is required by a population to produce the natural resources it consumes and to absorb waste with emphasis on carbon emissions. Higher ecological footprint is a reflection of deteriorating environmental conditions and is measured with global hectare (gha). FDI is foreign direct investment (% of Gross Domestic Product (GDP)). The study adopts trade (% of Gross Domestic Product (GDP)) to capture international trade utilized in the study of Iheonu et al. (2021). The study further includes GDP per capita in constant United States (US) dollar and Population, total, as control variables. These variables have been utilized in environmental sustainability literature such as Iheonu et al. (2021), Nathaniel, Anyanwu and Shah (2020), Martinez-Zarzoso, Bengochea-Morancho and Morales-Lage (2007). For ease of interpretation, the study converts ecological footprint, GDP per capita and population, total, to their natural logarithm. While ecological footprint data is obtained from the Global Footprint Network (2021), FDI, international trade, GDP and population are obtained from the World Development Indicator database (2021).

The study utilizes data for 37 African countries from 1990 to 2019. The data coverage is as a result of data availability. Countries involved in this study include: Algeria, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic (CAR), Chad, Comoros, Congo Republic, Cote d'Ivoire, Egypt, Eswatini, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Madagascar, Mali, Mauritania, Mauritius, Morocco, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Tanzania, Togo, Tunisia, Uganda, and Zimbabwe.

3.2 Methodology

This study employs the Pooled Mean Group (PMG) estimator proposed by Pesaran et al. (1999) in analyzing the effect of FDI and international trade on ecological footprints in Africa, which is a panel data variety of the autoregressive distributed lag (ARDL) model. According to Mahyideen, Ismail and Hook (2012), the panel analysis on the unrestricted specification for the ARDL model for t=1, 2,…,T and groups i=1, 2,…,N is given as:

$$y_{i,t} = \sum_{j=1}^{p} \lambda_{i,j}\, y_{i,t-j} + \sum_{j=0}^{q} \gamma'_{i,j}\, x_{i,t-j} + \mu_i + \epsilon_{i,t} \qquad (3)$$

where $y_{i,t}$ is the dependent variable, $x_{i,t}$ is the K× 1 vector of regressors for group i, μ_i denotes the fixed effects, $\lambda_{i,j}$ is the coefficient of the lagged dependent variable, and $\gamma'_{i,j}$ is a representation of the coefficients of the regressors.

The re-parameterized form of equation (1) is such that:

$$\Delta y_{i,t} = \vartheta_i y_{i,t-1} + \delta'_i x_{i,t-1} + \sum_{j=1}^{p-1} \lambda_{i,j}\, \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \gamma'_{i,j}\, \Delta x_{i,t-j} + \mu_i + \epsilon_{i,t} \qquad (4)$$

The PMG assumes that $\vartheta_i < 0 \forall$i's. This means that there exists a long run relationship between $y_{i,t}$ and $x_{i,t}$ which is defined by:

$$y_{i,t} = \omega' x_{i,t} + \eta_{i,t} \; i = 1,2,\dots,N; t = 1,2,\dots T \qquad (5)$$

where $\theta_i = \frac{-\delta'_i}{\theta_i}$, is the K× 1 vector of long-run coefficients and $\eta_{i,t}$ are stationary with possibly non-zero means which includes the fixed effects. Thus, equation (4) can be written such that:

$$\Delta y_{i,t} = \vartheta_i \eta_{i,t-1} + \sum_{j=1}^{p-1} \lambda_{i,j}\, \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \gamma'_{i,j}\, \Delta x_{i,t-j} + \mu_i + \epsilon_{i,t} \qquad (6)$$

In equation (6), $\eta_{i,t-1}$ is the error correction term, and ϑ_i is the coefficient of the error coefficient term which must be negative and significant and denotes the speed of adjustment to long run equilibrium. This parameter is expected to be negative and significant (Iheonu, Ihedimma and Omenihu 2017).

Prior to estimating the model, the study applies the Freidman test for cross-sectional dependence to examine the existence or non-existence of cross-sectional dependence in the model. The Freidman test proposed by Friedman (1937) according to De Hoyos and Sarafidis (2006) is a nonparametric test that is based on the Spearman's rank correlation. The Friedman statistic is based on the average Spearman's correlation given by:

$$R_{ave} = \frac{2}{N(N-1)} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{r}_{i,j} \quad (7)$$

where $\hat{r}_{i,j}$ is the sample estimate of the rank correlation coefficient of the residuals. Large values of R_{ave} denote the presence of cross-sectional correlations that are non-zero. The null hypothesis of no cross-sectional dependence is rejected on the premise that the probability value is less than conventional levels of statistical significance. Additionally, the Pesaran (2004) test would be used for robustness. The Pesaran test, as in the Friedmans test requires that N>T, and proposes a test equation for balanced panel data models, where:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \right) \quad (8)$$

The null hypothesis of the Pesaran test is similar to that of Friedman. The hypothesis of no cross-sectional dependence is rejected when the probability value of the test is viewed with conventional levels of statistical significance. Furthermore, the study tests for stationarity of the variables in the model using the Levin Lin Chu (2002) unit root test, the Im, Pesaran and Shin (2003) unit root test, and the Phillips-Peron Fisher unit root test (Maddala & Wu, 1999; Choi, 2001). These tests are first generation tests and are suitable in models no cross-sectional dependence. According to Iheonu et al. (2020), the LLC test is of the postulation that there is a common autoregressive parameter for all cross-sections while the IPS and PP-Fisher tests assume a difference of the autoregressive parameters for all cross-sections. The study utilizes the three tests for robustness purposes. Additionally, a panel cointegration test of Johansen Fisher developed by Maddala and Wu (1999) is utilized to examine whether a long run relationship exist in the model. The first-generation test of Johansen Fisher is suitable in the absence of cross-sectional dependence. The presence of long run relationship also verifies the utilization of the PMG estimator. Nonetheless, the Pedroni (1999, 2004) and the Westerlund (2007) panel cointegration tests would be employed for robustness of the Johansen panel cointegration test.

4. Presentation and Analysis of Results

This section presents the results of the study. It begins with simple descriptive statistics of the variables in the model and the correlation matrix before delving into more advanced statistical analysis. Table 1 shows the mean, standard deviation, minimum and maximum values of each of the variables in the model. Firstly, it is observed that the number of observations of the variables are similar—an indication that the data is balanced. We find that significant disparity exists between the minimum and maximum values of all the variables in the model. This signifies larger dispersion and possibilities of slope heterogeneity. We find the mean value of trade and FDI to be 63.6 and 2.5, respectively. The average value of population in the sample of African countries is about 17.9 million while per capita GDP on the average is $1631. Ecological footprint which is the dependent variable has a mean value of about 26,200,000 gha, a minimum value of 525,776 gha and a maximum value of 251,000,000 gha, revealing significant disparity in ecological footprints across countries.

Table 1: Summary Statistics of the Variables

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Ecological Footprint	1,110	2.62e+07	4.25e+07	524775.6	2.51e+08
FDI	1,110	2.5339	4.0630	-11.1989	46.2752
Trade	1,110	63.5949	27.2255	19.6841	175.798
Population	1,110	1.79e+07	2.68e+07	337953	2.01e+08
GDP	1,110	1630.887	1904.832	113.5674	11208.34

Source: Authors' computation.

Table 2 presents the correlation matrix and the test for cross-sectional dependence using the Friedman's procedure. Firstly, it is revealed that the regressors in the model are not strongly correlated, showing the absence of the possibility of multicollinearity. We however find that ecological footprint has a negative correlation with international trade and FDI, but a positive correlation with population and GDP. However, correlation does not imply causation and thus the need for advance econometric estimation.

Table 2: Correlation Matrix and Cross-Sectional Dependence Test

	Ecological Footprint	Trade	FDI	Population	GDP
Ecological Footprint	1.0000				
Trade	-0.3211	1.0000			
FDI	-0.0373	0.3152	1.0000		
Population	0.9480	-0.4391	-0.0651	1.0000	
GDP	0.0315	0.5233	0.1170	-0.1435	1.0000
Cross-Sectional Dependence Test					
Test			Statistics		
Friedman			26.188		
			(0.8852)		
Pesaran CD			-0.377		
			(0.7062)		

Source: Authors' computation. Note: Probability values are in parenthesis.

Table 2 also reveals that cross-sectional dependence do not exist in the model. This is because the probability value of the Friedman's test is greater than conventional levels of statistical significance. The result of the Pesaran CD test supports the conclusions of the Friedman test of no cross-sectional dependence. This is a justification of the utilization of first-generation panel econometric procedures. In Table 3, the results of the LLC and IPS unit root test are presented. The estimation procedure is based on specifications with the inclusion of a constant term and constant/trend for the LLC and IPS test, while the specification of the PP-Fisher test is based on the constant. The findings are that the variables are a combination of levels and first difference stationarity. In particular, the results reveal that across the specification of the LLC and IPS tests, ecological footprint and population is stationary in levels, except for the IPS unit root test in constant specification which is only stationary after first differencing. In the PP-Fisher unit root test, ecological footprint is revealed to be stationary only after first differencing. GDP on the other hand is seen to be stationary only after first differencing for both specifications and across all unit root tests. Trade and FDI on the other hand are strictly stationary in levels across the three unit root tests.

Table 3: Panel Unit Root Tests

Variables	LLC				IPS			
	Constant		Constant/Trend		Constant		Constant/Trend	
	Levels	F. diff	Levels	F. diff	Levels	F. diff	Levels	F. diff
Ecological Footprint	-2.7221***	-	-5.1483***	-	2.8882	-22.2067***	-4.8854***	-
Trade	-2.5303***	-	-2.7336***	-	-2.2030**	-	-2.2830**	-
FDI	-5.4002***	-	-5.1141***	-	-5.6981***	-	-4.8403***	-
GDP	-0.1210	-14.3336***	-1.0611	-11.8783***	4.4739	-14.9471***	-0.8308	-11.4396***
Population	-6.7918***	-	-36.9292***	-	8.1947	-22.0050***	-35.2632***	-
	PP-Fisher Test							
	Inverse chi-squared		Inverse normal		Inverse logit		Modified inverse chi-squared	
	Levels	F. diff	Levels	F. diff	Levels	F. diff	Levels	F. diff
Ecological Footprint	82.6228	1745.35***	1.8320	-37.7959***	1.1895	-79.3041***	0.7088	137.3848***
Trade	160.1467***	-	-3.6723***	-	-5.161***	-	7.0812***	-
FDI	290.3687***	-	-10.8449***	-	-12.64***	-	17.7854***	-
GDP	30.5922	785.1118***	5.0904	-23.7466***	4.7067	-35.6708***	-3.5681	58.4530***
Population	343.0707***	-	-5.2233***	-	-11.43***	-	22.1175***	-

Source: Authors' computation.

Note: Newey-West automatic bandwidth selection and Bartlett kernel. F. diff is First difference. *** and ** signifies statistical significance at 1% and 5%, respectively.

The results of the test signify a combination of levels and first difference stationarity. This is a precondition to the utilization of the PMG estimator. As earlier revealed, PMG constrains the long run relationship to be homogeneous but accounts for short run heterogeneity. The results of the unit root test mean that we can employ the PMG. However, we test for cointegration in the model using the Johansen Fisher cointegration test. This is only a sort of robustness test as the test is not a precondition to utilizing the PMG, and the test requires all variables in the model to be stationary at first difference. As revealed in Table 4, we find that a long run relationship exists among the variables in the model. This result is true for both the trace test and the maximum eigen test. The result shows that there are at most four cointegrating equations in the model.

Table 4: Johansen Fisher Panel Cointegration Test

Hypothesized No. of CE(s)	Fisher Statistic (trace test)	Probability	Fisher Statistic (max-eigen test)	Probability
None	1180	0.0000	873.7	0.0000
At most 1	499.0	0.0000	317.7	0.0000
At most 2	249.9	0.0000	166.0	0.0000
At most 3	147.9	0.0000	125.5	0.0002
At most 4	126.6	0.0001	126.6	0.0001

Source: Authors' computation.

Note: sample 1990-2019. Included observations: 1110. Trend assumption: Linear deterministic trend.

To support the results of the Johansen Fisher panel cointegration test, the Pedroni and the Westerlund tests are conducted. The findings support the conclusion of the Johansen test. The results show a clear case for cointegration among the variables in the model. All test statistics show the presence of long run relationship among the variables in the model at conventional levels of statistical significance.

Table 5: Pedroni Cointegration Test and Westerlund Cointegration Test

Pedroni		Westerlund	
	Statistic		Statistic
Modified variance ratio	-2.3593***	Variance ratio	-2.6390***
	(0.0092)		(0.0042)
Modified Phillips-Perron	-2.9230***		
	(0.0017)		
Phillips-Perron	-13.7204***		
	(0.0000)		
Augmented Dickey-Fuller	-13.3926***		

(0.0000)

Source: Authors computation.

Note: H0: No cointegration. Panel means are included in the computation. *** signifies cointegration at 1%.

In Table 6, three estimators are presented. The PMG, MG and DFE. Across the estimators, the long run result reveals a negative but insignificant impact of international trade on ecological footprint. This result is in consonance with the study of Hasanov et al. (2018) who found no significant relationship between international trade and the environment. FDI however has a positive and significant impact on ecological footprint in Africa, revealing that FDI increases environmental degradation. This supports the findings of Pham et al. (2020), Farooq et al. (2020) and Xu and Li (2021). In the MG and PMG models, no significant relationship exists between FDI and ecological footprint. Furthermore, it is revealed that the control variables have a positive impact of ecological footprints in Africa. The findings are that GDP per capita has a significant impact on ecological footprints in Africa in the PMG and DFE model but an insignificant impact in the MG model. The positive and significant impact of GDP per capita on ecological footprints supports the findings of Weimin et al. (2022). Across the estimators, it is also revealed that population is positively and significantly related to ecological footprints in Africa. Martinez-Zarzoso, Bengochea-Morancho and Morales-Lage (2007) support this finding of a positive influence of population on ecological footprints. The Hausman's test however, reveals that PMG is the preferred model against the MG and the DFE. The results reveal probability values greater than conventional levels of statistical significance. The homogenous short run result reveals no significant relationship between international trade, FDI and ecological footprints in the PMG and DFE models. It is however revealed that FDI has a negative and statistical impact on ecological footprint in the MG model.

Table 6: PMG, MG and DFE Results

Variables	PMG	MG	DFE
Long-Run			
Trade	-0.0658	-0.0826	-0.0222
	(0.134)	(0.443)	(0.835)
FDI	0.0034**	-0.0016	0.0056
	(0.013)	(0.712)	(0.157)
GDP	0.1732***	0.0646	0.1463***
	(0.000)	(0.129)	(0.001)
Population	0.7643***	0.8614***	0.7442***
	(0.000)	(0.000)	(0.000)
Short-Run			
ECT (-1)	-0.3955***	-0.8235***	-0.3091***
	(0.000)	(0.000)	(0.000)
D(trade)	-0.1033	0.0311	-0.0442
	(0.432)	(0.679)	(0.365)
D(FDI)	-0.0101	-0.0048*	-0.0002
	(0.202)	(0.090)	(0.872)
D(GDP)	0.0504	0.0397	0.0149
	(0.142)	(0.297)	(0.607)
D(population)	-0.9633	6.5898	0.3199
	(0.707)	(0.149)	(0.532)
Constant	1.1636***	1.6373	1.0592**
	(0.000)	(0.281)	(0.011)

Hausman Test	0.2161		1.0000
Number of Countries	37	37	37
Number of Observations	1073	1073	1073

Source: Authors' computation.

Note: ***, ** and * represents statistical significance at 1 percent, 5 percent and 10 percent, respectively.

The error correction term shows the presence of long run relationship in the estimators as the coefficients are negative and statistically significant. For the PMG model, it takes within three years to achieve long run equilibrium. For the DFE model, long run equilibrium is achieved within four years and the MG model shows that long run equilibrium will be achieved within a year and a quarter. However, country-specific short run results are presented Table 7, Table 8, Table 9, and Table 10.

Table 7: Pooled Mean Group Short-Run Results

Variables	Algeria	Benin	Botswana	Burkina Faso	Burundi	Cabo Verde	Cameroon	CAR	Chad
ECT (-1)	-0.6071***	-0.3000**	-0.3649**	-0.9913***	-0.2521**	-1.0610***	0.0106	-0.1241	-0.2066
	(0.000)	(0.017)	(0.011)	(0.000)	(0.041)	(0.000)	(0.807)	(0.162)	(0.110)
D(Trade)	-4.5797**	0.4110	-0.2535	0.0813	0.3345	-0.1982	0.1280*	0.0649	-0.0591
	(0.018)	(0.177)	(0.297)	(0.822)	(0.345)	(0.412)	(0.096)	(0.412)	(0.645)
D(FDI)	-0.2821*	-0.0168	0.0198**	0.0072	-0.0001	-0.0049	0.0019	-0.0031	0.0008
	(0.056)	(0.351)	(0.010)	(0.625)	(0.997)	(0.450)	(0.594)	(0.403)	(0.774)
D(GDP)	0.8894	0.1148	0.0767	-0.0061	0.0863	0.0222	-0.0252	0.0009	-0.0116
	(0.201)	(0.157)	(0.700)	(0.956)	(0.695)	(0.901)	(0.499)	(0.977)	(0.931)
D(Pop)	65.7340*	-8.9515	-2.6162	-40.3460**	-2.0778	2.3657	4.9255	2.0441*	1.9043
	(0.088)	(0.158)	(0.559)	(0.010)	(0.444)	(0.453)	(0.322)	(0.089)	(0.863)
Constant	0.5455	1.1489**	1.1680**	4.1738***	0.7443*	2.4498***	-0.1314	0.3254	0.6913*
	(0.394)	(0.032)	(0.021)	(0.000)	(0.063)	(0.000)	(0.546)	(0.187)	(0.057)

Source: Author's computation.

Note: ***, ** and * represents statistical significance at 1 percent, 5 percent and 10 percent, respectively.

In Table 7, we first find considerable differences in the speed of adjustment towards long run equilibrium which is as a result of the peculiarity of the individual countries. It is revealed that it takes less than a year for Cabo Verde to achieve long run equilibrium while it takes Burundi a little more than four years to achieve long run equilibrium. Nonetheless, findings show that Cameroon, CAR, and Chad do not achieve long run equilibrium. Furthermore, it is revealed that in the short run, international trade has a negative and significant impact on ecological footprint in Algeria but a positive and significant impact in Cameroon. Additionally, we find that FDI has a negative and significant impact on ecological footprint in Algeria but a positive and significant impact in Botswana. We also find population to be significantly propelling ecological footprint in Algeria and CAR but effectively reducing ecological footprint in Burkina Faso. The findings in Algeria reveal the importance of globalization in retarding environmental degradation, with the results supporting the pollution halo hypothesis. Furthermore, the pollution haven hypothesis is confirmed for Cameroon.

Table 8: Pooled Mean Group Short-Run Results

Variables	Comoros	Congo Rep	C. D'Ivoire	Egypt	Eswatini	Gabon	Gambia	Ghana	Guinea
ECT (-1)	-0.5166***	-0.7504***	-0.3375*	-0.0926	-0.4361***	-0.3729**	-0.7085***	-0.1567*	-0.1387
	(0.001)	(0.000)	(0.061)	(0.156)	(0.009)	(0.012)	(0.000)	(0.071)	(0.126)
D(Trade)	0.6810	-0.0323	0.4234**	0.1051	0.4373*	-0.4128	0.0848	0.0069	0.1225
	(0.606)	(0.733)	(0.022)	(0.336)	(0.065)	(0.370)	(0.568)	(0.943)	(0.479)
D(FDI)	-0.0726**	-0.0007	0.0083	0.0124***	0.0075	0.0087	-0.0204***	-0.0019	-0.0018
	(0.020)	(0.554)	(0.584)	(0.000)	(0.219)	(0.325)	(0.002)	(0.703)	(0.539)
D(GDP)	-0.1653	-0.2193***	0.2324**	0.1944***	0.4899**	-0.0977	0.0574	0.0524	0.0459
	(0.241)	(0.005)	(0.026)	(0.001)	(0.015)	(0.657)	(0.528)	(0.424)	(0.657)
D(Pop)	12.1786	-8.5103	-0.3491	0.3291	-4.2574	9.126	-3.1664	-2.5302	-3.0077
	(0.167)	(0.111)	(0.885)	(0.927)	(0.167)	(0.240)	(0.743)	(0.702)	(0.484)
Constant	0.8260**	2.0283***	1.0001*	0.3399	1.2321**	0.6978**	1.7598***	0.6275	0.5321*
	(0.044)	(0.000)	(0.078)	(0.170)	(0.012)	(0.049)	(0.006)	(0.157)	(0.099)

Source: Authors' computation.

Note: ***, ** and * represents statistical significance at 1 percent, 5 percent, and 10 percent, respectively.

In Table 8, we find similar disparity in the error correction term in reference to the speed of adjustment towards long run equilibrium. Furthermore, it is revealed that in the short run, international trade has a positive and significant impact on ecological footprint in Cote d'Ivoire and Eswatini. FDI is seen to have a negative and significant relationship with ecological footprint in Comoros and Gambia but a positive and significant impact in Egypt. We further find that GDP significantly increases ecological footprints in Cote d'Ivoire, Egypt and Eswatini but reduces ecological footprints in the Congo Republic. Table 9 further reveals that international trade significantly reduces ecological footprints in Mauritania and Morocco while FDI significantly increases ecological footprint in Mauritania. Additionally, GDP significantly increases ecological footprints in Morocco while population is seen to significantly propel ecological footprints in Kenya but significantly reduce ecological footprint in Guinea Bissau and Mauritius.

Table 9: Pooled Mean Group Short-Run Results

Variables	G-Bissau	Kenya	Madagascar	Mali	Mauritania	Mauritius	Morocco	Namibia	Niger
ECT (-1)	-0.4622***	-0.2042**	-0.0588	-0.4379***	0.0413	-0.7019***	-0.3550***	-0.6528***	-1.0116***
	(0.001)	(0.017)	(0.438)	(0.004)	(0.686)	(0.000)	(0.008)	(0.000)	(0.000)
D(Trade)	-0.2697	0.0114	0.0111	-0.0903	-0.2201***	0.0974	-0.8354***	-0.3199	-0.0641
	(0.145)	(0.925)	(0.901)	(0.618)	(0.006)	(0.442)	(0.006)	(0.504)	(0.890)
D(FDI)	-0.0073	-0.0002	0.0021	-0.0001	0.0029***	0.0014	-0.0011	-0.0111	-0.0031
	(0.505)	(0.981)	(0.523)	(0.976)	(0.005)	(0.769)	(0.883)	(0.303)	(0.774)
D(GDP)	-0.1790	-0.0012	0.0580	0.0533	-0.0856	-0.0905	0.4964**	-0.0862	0.1833
	(0.125)	(0.984)	(0.228)	(0.541)	(0.160)	(0.437)	(0.025)	(0.766)	(0.158)
D(Pop)	-15.9305*	9.9683**	0.9557	5.7003	-1.3736	-6.3346**	-9.5991	3.8077	15.1182
	(0.061)	(0.033)	(0.851)	(0.155)	(0.796)	(0.026)	(0,267)	(0.686)	(0.139)
Constant	1.6081***	0.3691	0.1608	1.2504***	-0.0600	2.1125***	1.2646**	1.8510***	2.7777***
	(0.005)	(0.101)	(0.317)	(0.006)	(0.837)	(0.001)	(0.016)	(0.007)	(0.000)

Source: Authors' computation.

Note: ***, ** and * represents statistical significance at 1 percent, 5 percent, and 10 percent, respectively.

In table 10, we do not find any significant relationship between international trade and ecological footprints. However, we find that FDI significantly reduces ecological footprint in Togo revealing the existence of the pollution halo hypothesis. The result also reveals that GDP has a statistically significant impact on ecological footprint in Zimbabwe while population has a negative and significant impact on ecological footprint in Nigeria, Senegal, and Tunisia but a positive and significant impact in Rwanda and Togo. For Rwanda, the study of Imasiku andNtagwirumugara, (2020) has found similar results.

Table 10: Pooled Mean Group Short-Run Results

Variables	Nigeria	Rwanda	Senegal	Sierra Leone	South Africa	Tanzania	Togo	Tunisia	Uganda	Zimbabwe
ECT (-1)	-0.2029*	-0.3332**	-0.9051***	-0.4943***	-0.2852**	-0.0654	-0.4463***	-0.5441***	0.0024	-0.1087
	(0.090)	(0.013)	(0.000)	(0.000)	(0.033)	(0.323)	(0.002)	(0.000)	(0.953)	(0.271)
D(Trade)	0.1167	0.0405	0.0358	0.0259	0.0017	0.1591	0.1255	-0.0604	-0.0891	0.1546
	(0.157)	(0.762)	(0.895)	(0.626)	(0.995)	(0.520)	(0.213)	(0.766)	(0.450)	(0.144)
D(FDI)	-0.0016	0.0001	-0.0082	-0.0007	-0.0063	0.0066	-0.0039**	-0.0045	0.0057	-0.0059
	(0.811)	(0.994)	(0.552)	(0.491)	(0.379)	(0.465)	(0.019)	(0.479)	(0.342)	(0.350)
D(GDP)	0.0288	0.0094	-0.0421	-0.0265	-0.0833	-0.1624	-0.0240	-0.1009	-0.0023	0.1837**
	(0.553)	(0.906)	(0.710)	(0.570)	(0.411)	(0.292)	(0.694)	(0.633)	(0.950)	(0.022)
D(Pop)	-34.1362**	0.4716**	-13.7271*	-0.3527	-3.4893	-6.6154	8.0249**	-9.3466***	-0.8154	-0.7651
	(0.014)	(0.043)	(0.060)	(0.429)	(0.271)	(0.194)	(0.011)	(0.008)	(0.792)	(0.709)
Constant	1.5875**	0.8251**	3.0184***	1.3775***	1.2084**	0.3511	1.0026**	1.8177***	0.0344	0.3367
	(0.027)	(0.042)	(0.000)	(0.002)	(0.037)	(0.102)	(0.015)	(0.002)	(0.873)	(0.289)

Source: Authors' computation.

Note: ***, ** and * represents statistical significance at 1 percent, 5 percent, and 10 percent, respectively.

5. Concluding implications and future research directions

This study has examined the influence of FDI and international trade on environmental sustainability in Africa employing data from 1990 to 2019 for 37 African countries. The study utilized the PMG estimation strategy which accounts for short run heterogeneity but constrains the long run results to be homogenous. The findings show that in the long run, FDI increases ecological footprints in Africa and as such leads to environmental degradation supporting the pollution haven hypothesis. Further long run result show no significant relationship between international trade and ecological footprint. In the short run, it is revealed that FDI has a negative effect on ecological footprints in Algeria, Comoros, Gambia, and Togo but positively influences ecological footprint in Botswana, Egypt and Mauritania. It is also revealed that international trade has a negative effect on ecological footprint in Algeria, Mauritania, and Morocco but a positive influence in Cameroon, Cote d'Ivoire and Eswatini.

The results confirm heterogeneous short run effects and the need for country-specific short run policies in improving environmental sustainability in Africa. In particular, deliberate policies which ensure the enhancement of international trade in Algeria, Mauritania and Morocco should be prioritized to ensure the improvement of the environment. This is important because improvement in trade spurs economic activities and simultaneously enhance the environment. This requires the need for the government to enhance access to finance aimed at improving local productivity and export base. This is even as international trade aid in the transfer of new and advanced technologies. Additionally, policies that see the increase in FDI should be implemented in Algeria, Comoros, Gambia and Togo. Such policies can include improving the ease and reducing the cost of doing business, improving property rights as well as economic and legal infrastructure. However, in Cameroon, Cote d'Ivoire and Eswatini, there is a need to restrict international trading activities and deliberate policies aimed at regulating trading activities which are not friendly to the environment. Additionally, the need for the improvement in institutional quality becomes paramount in controlling FDI inflow in Botswana, Egypt, and Mauritania. In this sense, the government must implement sound policies and regulations for foreign investors by making it mandatory to adopt green energy. Moreover, the government can also introduce incentives such as tax holidays for investors who adopt green energy.

The finding above and corresponding policy prescriptions obviously leave room for further research, especially within the remit of assessing how international trade and FDI affect other sustainable development goals (SDGs) of the United Nations, *inter alia*, poverty reduction, gender equality and inequality mitigation. Along the suggested future lines of inquiry, as apparent in the present study, country-specific studies should be prioritized in order to provide more country-specific policy implications.

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Appendix A: Pesaran (2015) Cross-sectional Dependence Test

Test-Statistics
141.337***
(0.000)
136.464***
(0.000)
83.351***
(0.000)
141.185***
(0.000)
141.348***
(0.000)