Consumption-Base Carbon Emission And Foreign Direct Investment In Oil Production Sub-Sahara African Countries: The Role of Natural Resources and Urbanization

Bright Akwasi Gyamfi (brightgyamfi1987@gmail.com)
Cyprus International University https://orcid.org/0000-0002-7567-9885

Research Article

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Posted Date: May 4th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-417475/v1

Consumption-base carbon emission and foreign direct investment in oil production Sub-Sahara African Countries: the role of natural resources and urbanization.

Bright Akwasi Gyamfi
Faculty of Economics and Administrative Sciences
Cyprus International University
Nicosia, North Cyprus
Via Mersin 10, Turkey
Email: brightgyamfi1987@gmail.com

Abstract.

The intensification of international trade movements and economic interconnectivity has far-reaching ramifications for many macroeconomic indicators, not to mention ecological consequences. To this end, this analysis examine the dynamic interaction between foreign direct investment (FDI), natural resources, economic advancement and urbanization on consumption-based carbon emission which is adjusted for global trade for oil production Sub-Saharan Africa countries. The time frame for this analysis is from 1990 to 2018. To examine the nature of relationship between the outlined variables, we rely on a balanced panel econometrics analysis alongside Augmented Mean Group (AMG), Common Correlated Effect Mean Group (CCEMG) and the Driscoll–Kraay (DK) OLS techniques. The analysis presented a uniform outcomes from all the estimators showing a positive association among all the variables (natural resource, FDI, income and urbanization) and consumption-based carbon pollution. This therefor affirms the pollutant haven hypothesis for the countries under consideration. This suggests that foreign direct investment inflow has a detrimental influence on the host country alongside natural resource. Finally, these outcomes suggest the need to pursue low-carbon strategies for a cleaner and friendly environment

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1. Introduction.

Humankind faces major new challenges due to the increasing environmental emissions of greenhouse gases It is obvious that over the last decade, humanity' lifestyle has contributed significantly to the rise in the amount of heat-trapping pollutants to the levels not observed in the last 800,000 years (Nunez, 2019). Since the late 1800s, atmospheric sea level has risen by 178 millimeters while carbon pollution in the atmosphere have increased to levels that have never been seen before in 650,000 years, the Iceberg has melted away by a total of 1.9 F because of the increasing emission (NASA, 2020). However, even if carbon dioxide pollution are to be reduced, upcoming generation will be harmed by the same amount as existing ones. This is why actions such as the Paris Agreement in 2016, especially as carbon reduction steps are now in the process which are mandatory rather than a discretionary (Shen et al. 2021). Base on this assumption, elements of heat-trapping gases, particularly CO_2 pollution have gain much interest whiles there is an indication that, energy usage (Zhang and Cheng, 2009), population (Begum et al., 2015), urbanization (Wang et al., 2016), human capital (Bano et al., 2018), financial development (Gu et al., 2020), research & development (Pablo-Romero and Sánchez-Braza, 2015), natural resources (Umar et al., 2020) as well as trade liberalization (Hakimi and Hamdi, 2016) are among the specific causes of CO_2 pollution and others.

This is reinforced by a conviction that offshore investment is beneficial to the global economy on the whole, but critics of international investment regard it as a tool for the wealthiest countries to minimize their environmental impact. A drop in the total pollution is to be (at least) compensated by an increase in the pollution in areas where products and resources are produced – recognized as Carbon-Leakage (Liddle, 2018). According to the "Pollution Heaven Hypothesis, (PHH)" investors imposes massive global-scale polluters on impoverished nations where environmental regulations are permissive (Cole, 2004). Additional, the major trigger of ecological degradation is natural resource exploitation as a result of massive economic growth (Sarkodie 2018). The exploitation of natural resources has nearly doubled in the last century with the volume of gas, coal, and oil tripling, for example increasing from 6 to 15 billion tons (Aziz et al 2020). The mass of the biomass increased from 9 to 24 billion, as well as new capital doubled in volume (Global IRP 2019). This claim has been supported by Giljum et al. (2009), who found that the amount of natural resources seized by humans is equivalent to half of what was formerly taken over 30 year (for reference, it was around 60 billion tons). Furthermore, this overuse of resources will surpass the world's regenerative capacity

(Global Footprint Network 2017). It is therefore crucial to address issues about natural resources and international investment in the development process.

Nonetheless, priority is still directed to pollutions generated inside a country's territorial boundaries, i.e., production-based pollution. While other consumption-based carbon pollution which are balanced towards foreign direct investment and trade, attract comparatively little consideration (Spaiser et al., 2019). Nonetheless, others argue that previous steps are insufficient to accurately estimate carbon pollution. For example, it ignores the fact that developed countries are specialized in utilities as well as knowledge-based industries, which emit less carbon dioxide than industries or agriculture-based countries (Baker, 2018). Additionally, products bought by rich countries are manufactured in emerging countries, therefore, carbon pollution associated with their manufacture are linked to these emerging countries (Scott and Barrett, 2015).

As a result, developed countries appear to be decreasing their carbon pollution, as suggested by the extremely dubious Inverted-U shaped environmental Kuznets curve (Stern et al., 1996). They do, nevertheless, fulfill this increasing demand from emerging economies (Davis and Caldeira, 2010). Thus, the pollution contained in consumption call into question the credibility of the findings that the amount of pollution declines from a specific income level; since such pollution (consumption-based pollution) cannot be divorced from the increasing income level, that facilitates investment intensity and scale of pollution globally (Steinberger et al., 2013). Consequently, a consumption-based strategy is potentially more suitable for encompassing the overall pollution chain ensuring accountability for carbon stocks, or assessing the efficacy of world efforts to mitigate increasing pollution (Fernández-Amador et al., 2017). Additionally, empirical research indicates that FDI has a considerable influence on consumption-based pollution but has no influence on territory-based pollution (Knight and Schor, 2014; Liddle, 2018a; Hasanov et al., 2018).

Regrettably, prior research on FDI and carbon pollution has focused primarily on production-based pollution, whereas overlooking consumption-based pollution (Liddle, 2018). Subsequently, prior research investigated the causal relation in consolidated trade environments, omitting the differentiated impact of FDI, i.e., whether FDI inflows and outflows influence the rate of carbon pollution independently (Hasanov et al., 2018). Additionally, recent research on FDI and carbon pollution takes into account a variety of countries, including the OECD (Cole, 2004), the European Union (De Almeida Vale et al., 2016), and a mix of advanced and emerging economies (Spaiser et al., 2019; Jiborn et al., 2018). Moreover, exclusively disregard the impact of foreign direct investment on carbon pollution in oil-importing economies. To our understanding, only Hasanov et al. (2018) and Khan et al. (2020) have investigated this aspect. Regarding this void, the primary purpose of this analysis is to investigate how foreign direct investment (FDI) and natural resources influence the level of carbon emissions (consumption-based) in oil countries of the Sub-Sahara African countries.

African nations, such as Angola and Nigeria, are the main oil-producing economies with a daily production of 1.7 million and 1.5 million barrels from 2016 and continue to rise monthly. Thus, Nigeria produces 300 oil spills annually to damage the climate (U.S. Energy Information Administration 2013). The African continent alone has deaths over 770,000 annually due to air pollution including Carbon pollutions and this also has a detrimental impact on people's health. Pollutions of biomass gasification greenhouse gases, food yield lefts, land gas, litter, and alcoholic fuels result in more than 40,000 deaths (Bauer et al. 2019). Amegah and Agyei-Mensah (2017) stated that, airborne pollution has triggered some degree of disability and decrease in overall years to more than 600,000 citizens in the sub-Saharan region. Industrial economies are in danger of generating more carbon dioxide, since figures show that industrial practices contribute more than 30 percent to global use of energy and generate 20 percent of global carbon Dioxide emissions that affect human health (Acar and Tekce 2014; Sarpong and Bein, 2020, Sarpong et al. 2020). The African continent is also at risk of poor ecosystem quality as it continues to industrialize its economies.

As stated early, the main purposes of this analysis is to examine the impact of FDI and natural resources on carbon pollution (consumption-based) in case of Sub-Sahara African countries. This analysis however contribute to the existing studies in different forms: (i) The target of this review is to plug the gap of insufficient information on the PHH for Sub-Saharan Africa (SSA) and to contribute to the existing study by not focusing exclusively on Sub-Saharan African nations as a unit and, instead, separating SSA into oil-producing and non-oil-producing nations in order to gain a better understanding of the pollution haven hypothesis (PHH) from the oil-producing nations. Thus, this present study differs from prior ones such as (Keho, 2015; Acheampong et al., 2019) in that they examined the complexities of FDI's impact on Carbon emission in the area's oil-producing countries and provided policymakers with a range of recommendations based on the findings. (ii) Unlike other studies that used the CO_2 emission as a whole (Gyamfi et al. 2020a, b, Sarpong et al. 2020, Ampoma et al. 2021, Adedoyin et al 2021), this study utilized the consumption-based carbon pollution which to our best of knowledge has not be used for the sub-Sahara African context. (iii) The effect of natural resources on the consumption-based carbon pollution is also analysis in this study. (iv) Lastly, Our study employs a novel econometrics techniques in the framework of cross-sectional dependency test to identify either to go for the first generation or second-generation estimation approach which allow our study to utilize a more robust technique for this investigation. We utilize the Pesaran (2015) LM test, Pesaran (2007) CD and Breusch-Pagan (1980) LM test to evaluate for cross-sectional dependence as well as Pesaran (2007) panel root unit test to examine the integration features of variables. Subsequently, we utilize Westerlund (2007) test to analyze the long-run equilibrium relationship among highlighted variables. To evaluate the long-run coefficients of the variables, the ordinal least square (OLS), Augmented Mean Group (AMG) and Common Correlated Effect Mean Group (CCEMG). More attention was placed on the results from the Augmented Mean Group (AMG) and Common Correlated Effect Mean Group (CCEMG) estimation techniques for checking the long-term relationship between FDI, economic growth, natural resources fossil fuel and consumption-based carbon pollution (CCO_2) for the period of 1990 to 2018.

This study is structured as follows. The first section is the introduction. The second section is the literature review. The third section is the methodology and model design. The fourth section includes results and analysis while the final section concludes the study with policy directives.

2. Literature Review

This study explores how consumption-based Carbon pollution affect the climate. The information in this portion on consumption-based carbon emissions, foreign direct investment, natural resources, economic advancement and fossil fuels includes recent publications by Liddle (2018b); Dong et al. (2016); Mensah et al. (2018) and Shahbaz et al. (2018).

From the year 1990 to 2013, Liddle (2018b) evaluated the influence of international investment, energy costs, industrial value added, and fossil fuel use in 102 nation’s territory- and use-based carbon pollution. The outcome indicated that GDP reduces emissions, but imports raise territory pollution. As imports and GDP rise, so does consumption-based carbon pollution. Usage and industrial share of fossil fuels grow, whereas energy costs decrease consumption and territory-based carbon pollution.

Hasanov et al. (2018) analyzed oil-exporting nations' consumption-based pollution and international investment from 1995 to 2013. The outcomes shown that GDP and imports have a positive impact on consumption-based carbon pollution, whereas exports have adverse influence on consumption-based carbon pollution. Imports as well as exports also contribute to a decrease in territory-based carbon pollution, while GDP contributes to a rise in it.

Dong et al. (2016) investigated the international panel's environmental Kuznets curve (EKC) utilizing both consumption- and production-based carbon pollution. The authors noted that for consumption-based carbon pollution, the environmental Kuznets curve (EKC) assumption does not hold. Additionally, EKC for consumption-based carbon pollution is considered stable and rising.

Using selected 18 Latin American countries, Blanco et al. (2013) examined FDI-CO_2 connection between 1980 and 2007. To establish the research objectives, the investigators used panel Granger causality test and the outcomes disclose one-way causality running from FDI to CO_2 pollutions in the selected countries. Omiri et al. (2014) explored the dynamics between FDI and CO_2 pollutions in 54 nations over the duration of 1990–2011 utilizing panel techniques and established feedback causal linkage between CO_2 emissions and FDI. Using data stretching from 1974–2010, Gökmenoğlu & Taspinar, (2016) evaluate the effect of FDI on ecological dilapidation in Turkey. The authors used ARDL and Toda–Yamamoto causality tests to ascertain this connection and the findings disclose that FDI inflows exert a positive effect on CO_2 pollution which illustrates that a rise in FDI harm the sustainability of the environment. Furthermore, there is proof of two-way causality among FDI and CO_2 emissions. Moreover, He et al. (2020) observed the FDI-CO_2 interconnection using the bootstrap ARDL test in BRICS nations and the outcomes disclose that FDI and CO_2 pollution are connected positively implying that FDI harm the sustainability of the environment in the BRICS nations. From a different point of view, the investigation of Ahmad et al. (2021) on the FDI-CO_2 association in OECD economies from the period 1990 to 2014 disclosed that FDI-CO_2 association is negative and statistically significant which gives room for the support of the Pollution Halo Hypothesis in the OECD nation. Adeel-Farooq et al. (2021) in their study on the interconnection regarding FDI inflows and pollutions, uncovered that FDI inflows exert a significant and detrimental impact on the sustainability of the environment in developing countries while FDI inflows improve the sustainability of the environment in advanced economies. Essandoh et al. (2020) assessed the association between CO_2 and FDI in 52 developed and developing countries from the period 1991–2014. The investigators' utilized PMG-ARDL test and the findings uncovered that FDI inflows increase environmental degradation in emerging nations while FDI inflows decrease ecological degradation in advanced economies. Furthermore, the study of Haug & Ucal (2019) using nonlinear techniques assesses the linkage between FDI and CO_2 emissions in Turkey between 1975 and 2014. The investigators found an insignificant connection between FDI and CO_2 emissions.

Badeeb et al. (2020) examined the impact of natural resources on ecological sustainability within the EKC system using ARDL as well as structural break co-integration. Their analytical results suggest that natural resource dependency is consistent with the relationship regarding economic advancement and ecological sustainability. Balsalobre-Lorente et al. (2018) examined the impacts of natural resources to Carbon pollution in five EU nations and found that natural resources enhanced ecological sustainability from 1985 to 2016. Cheng et al. (2020) discovered that China's green sustainable prosperity is plagued by natural resource scarcity. Danish et al. (2020) demonstrated that natural resource rent leads to the degradation of the atmosphere in BRICS nations. Danish et al. (2019) identified that natural resource availability decreases Carbon pollution in Russia but deteriorates ecological efficiency in South Africa by analyzing the role of natural resources and energy use on CO_2 pollution in the BRICS countries. Additionally, their analytical review discovered that natural resources in BRICS countries could aid in the formation of the EKC concept

After reviewing the above-mentioned studies, we can identify a number of shortcomings in existing literature. First, existing literature have focused on CO_2 emissions directly generated through the use of fossil fuels in domestic production, neglecting the growing environmental impact of FDI-induced consumption patterns in the sub-Sahara Africa economies. Second, existing studies have provided limited policy considerations on possible synergies among FDI, natural resources and fossil fuel Therefore, in order to solve the above research deficiencies, the innovations of this paper include the use of disaggregated carbon emissions data, which accounts for the differential effects of consumption patterns in Sub-Sahara Africa economies, and the extension of empirical modelling framework to account for the synergies between FDI, natural resources and fossil fuel targets.

3. Data and Methodology

3.1 Data

This study utilized yearly data series over the period 1990 – 2018. Data on consumption-based carbon emissions are from the Global Carbon Budget (Friedlingstein, et al., 2019).Consumption-based method adds emissions embodied in imports and subtracts emissions embodied in exports (consumption-based emissions = production-based emission + emissions in imports – emissions in exports) (see Peters et al., 2012). However, while empirical analysis focuses on consumption based CO_2 pollution as a major measure of ecological dilapidation, variable such as natural resources FDI, economic growth, and urban population are used as regressors and are obtained from the WDI, (2020) for the oil production Sub-Sahara African countries. The full description of the variables in the modelled relationship in equation 1 is provided with their corresponding measurements and sources in Table 1. Given the strong appealing arguments in contemporary studies with respect to the crucial roles of natural resource rent and FDI in ecological degradation (Sinha & Sengupta, 2019; Khan et al. 2021; Guan et al. 2020), this study accounts for the roles of these variables while exploring the impacts of fossil fuel and urbanization on the environmental quality of the oil production Sub-Sahara African economies.

Table 1. Description of variables

VARIABLES	MEASURMENT	SOURCES	SYMBOLS
Consumption-Based CO_2 Emissions	Metric tons per capita	Friedlingstein, et al., 2019	CCO_2
GDP per Capita	In constant 2010 USD	WDI (2020)	Y
Urbanization	Urban population (% of total population)	WDI (2020)	UP
Natural resources	Total natural resource rent (% of GDP)	WDI (2020)	NRR
Foreign Direct Investment	% of real GDP	WDI (2020)	FDI

Sources: author's compilation, 2020. Note Global Carbon Budget (Friedlingstein, et al., 2019) is available at https://doi.org/10.5194/essd-11-1783-2019; WDI available at https://databank.worldbank.org/source/world-development-indicators#advancedDownloadOptions; Data on FF are from two sources; 1990-2015 from WDI, World Bank while estimates for 2016 and 2018 are from the SDG Indicators Global Database, United Nations available online at: https://unstats.un.org/sdgs/indicators/database/

LIST OF COUNTRIES:	Algeria, Angola, Cameroon, Chad, Congo, Rep., Cote d'Ivoire, Egypt, Gabon, Libya, Morocco, Nigeria, Sudan and Tunisia

3.2 MODEL

The STIRPAT framework is the basis of this study. The STIRPAT assumption states that the damage of the environment is both economic and societal.

$$I_t = \vartheta_o P_t^{\xi 1} A_t^{\xi 2} T_t^{\xi 3} \mu_t \qquad (1)$$

From Eq. 1, I is an indicator of environmental degradation, P, A, and T denotes inhabitants, wealth, as well as innovation correspondingly. φ1 - φ3 as well as μ are the variables assessors and the error term correspondingly. T may be separated founded on the drive of the analysis (Bello et al. 2018; Nathaniel et al. 2020). In consistence to the various studies of Solarin and Al-Mulali studies (2018) and Nathaniel et al. (2020), I, in this analysis is identified as consumption-based CO_2 emission as already mentioned. From another point of view, P as well as A are represented by economic growth and FDI correspondingly. This study then utilized urbanization (UP), natural resources rent (NRR), as well as foreign direct investment (FDI), as a proxy T. The drawn-out is presented as:

$$I_t = \vartheta_o Y_t^{\xi 1} \, NRR_t^{\xi 2} \, FDI_t^{\xi 3} \, UP_t^{\xi 4} \, \mu t \quad (2)$$

By converting the logarithm of each of the variables, the method is advance expressed as, expect FDI which was left in its normal form;

$$LnI_{it} = \alpha_0 + \alpha_1 Ln\mathrm{Y}_{it} + \alpha_2 Ln\mathrm{NRR}_{it} + \alpha_3 FDI_{it} + \alpha_4 Ln\mathrm{UP}_{it} + \varepsilon_{it} \quad (3)$$

Where Y, NRR, FDI, and UB denote economic growth, natural resources, foreign direct investment, and urbanization. I, from a different point denote the ecological element utilized in this studies, thus, consumption-based CO_2 pollution. To examine the effect of Y, NRR, FDI, and UP on I the authors formulated Eqs. (4) which is shown as;

$$LnCCO2_{it} = \alpha_0 + \alpha_1 Ln\mathrm{Y}_{it} + \alpha_2 Ln\mathrm{NRR}_{it} + \alpha_3 FDI + \alpha_4 Ln\mathrm{UP}_{it} + \varepsilon_{it} \quad (4)$$

While the residual factors uphold their unique explanation, CCO_2 denote consumption-based CO_2 emission.

3.3. Cross-sectional Dependency Technique and Panel Unit root Analysis

Firstly, as a major step into choices of methodological framework for the current study vis-à-vis the possibility of interdependence among the oil production economies in the Sub-Sahara Africa continent, we have ensured that a cross-sectional dependency (CD) test was conducted. Contemporary studies have vastly enunciated the significance of such action as an important step towards ensuring not just the right model selection but to also ensure the robustness of estimated coefficients for a panel study where analysis is done on observations that are drawn from samples that are bound to be cross-sectionally dependent (Shahbaz et al. 2018; Shahbaz et al. 2019; Wang et al. 2020; Gyamfi et al. 2021; Shen et al. 2021). To this end, we adopted Pesaran (2007) CD test, the Pesaran (2015) and the Breusch-Pagan (1980) LM test for the cross-sectional dependency test. The conducted CD test provided evidence of cross-sectional dependence in the panel analysis and this primarily implies that conducting a direct unit-root test using the first-generation techniques without factoring in the possibility of cross-sectional dependence would have resulted into an exercise in futility (Im et al., 2003). Consequently, we applied the second generation IPS (CIPS) unit root test of Pesaran (2007) following the model in equation 5.

$$\Delta Y_{it} = \Delta\varphi_{it} + \beta_i X_{it-1} + \rho_i T + \sum_{j=1}^{n} \theta_{ij} \Delta X_{i,t-j} + \varepsilon_{it} \quad (5)$$

In equation 5, X_{it} stands for the understudied variables while φ_{it} and T are the intercept and time span respectively. Δ and ε_{it} are difference operator and model error term accordingly. In addition to the CIPS results, the panel IPS results was reported to double check the results from the CIPS concerning the stationarity nature of the variables.

3.4 Panel Cointegration Analysis

To bypass the pitfalls in using first generation cointegration approaches in testing for cointegration in presence of cross-sectional dependence, we have adopted the Westerlund (2007) technique to examine long-run relationship among the variables. The application of the approach for cointegration checks follows the steps follows the error adjustment process in equation 3.

$$\Delta Y_{it} = \delta_i d_t + \phi_i Y_{it-1} + \lambda_i X_{it-1} + \sum_{j=1}^{pi} \phi_{ij} \Delta Y_{i,t-j} + \sum_{j=0}^{pi} \gamma_{ij} \Delta X_{i,t-j} + \varepsilon_{it} \quad (6)$$

In equation 6, $\delta_t = (\delta_{i1}, \delta_{i2})'$, $d_t = (1, t)'$, and ϕ present a vector for the parameters, the deterministic terms, and the error adjustment term respectively. Identifying the long-run relationship is simply based on the produced group mean statistics and the panel's statistics following the least square estimation of the ϕi parameter in equation 6. To identify cointegration existence, Westerlund (2007) approach produces four major statistics based on the least square estimation and corresponding significance of the adjustment term ε_{it} of the ECM model in Eq. 6 and these statistics can be categorized under two major subdivisions namely the group statistics and the panel statistics. The group mean statistics $G\tau$ and $G\alpha$ follows the derivations from the expressions in Eq. 3 and Eq.4;

$$G\tau = \frac{1}{N} \sum_{i=1}^{N} \frac{\hat{} \propto i}{SE(\hat{} \propto i)} \quad (7)$$

$$\text{G}\alpha = \frac{1}{N}\sum_{i=1}^{N}\frac{T^{\wedge} \propto i}{^{\wedge} \propto i(1)} \tag{8}$$

Where, $^{\wedge} \propto i$ is denoted by $SE(^{\wedge} \propto i)$ as the standard error. The semiparametric kernel technique of $\propto i(1)$ is $^{\wedge} \propto i(1)$.

$$\text{P}\tau = \frac{^{\wedge} \propto i}{SE(\propto i)} \tag{9}$$

$$\text{P}\alpha = \text{T}\alpha^{\wedge} \tag{10}$$

The two remaining panel mean techniques shown that the entire panel is co-integrated is presented in Eq. 9 and Eq. 10, where variables remained as earlier defined. The application of this test has been substantially reported in the literature as they are designed to accommodate cross-sectional dependency in a panel study (Le and Ozturk, 2020; Alola et al., 2019; Nathaniel et al., 2020).

3.5 Long-run Panel Coefficient Estimation Techniques

This study adopted the Augmented Mean Group (AMG) estimator of Eberhardt and Bond (2009) and Eberhardt and Teal (2010)), and the advanced Common Correlated Effect Mean Group (CCEMG) panel estimator of Kapetanios et al. (2011) as initially developed by Pesaran (2006) for the long-run panel estimations. In addition, while we focus on the AMG and the CCEMG estimates due to its statistical strengths that has triggered the rise in its application in contemporary studies (Nathaniel et al. 2021; Wang et al. 2020), were utilized in the study following the expression in Eq. 11 and Eq. 12 respectively:

$$\Delta Y_{it} = \alpha_i + \beta_i \Delta X_{it} + \sum_{t=1}^{T} \pi_t D_t + \varphi_i UCF_t + \mu_{it} \tag{11}$$

$$Y_{it} = \alpha_i + \beta_i X_{it} + \gamma_i Y^*{}_{it} + \delta_i X^*{}_{it} + \theta_i UCF_t + \mu_{it} \tag{12}$$

From the CCEMG expression in Eq. 12, the Y^* and X^* represent the mean values of the variables Y_{it} and X_{it} alongside the unobserved common effects while D is a time variant dummy variable in the Eq. 7.The OLS estimation of the differenced Eq. 11 is utilized to generate the AMG estimator as given in Eq. 13 where φ_i denotes the estimated slope parameters of the X_{it} variable in Eq. 11.

$$\mathrm{AMG} = \frac{1}{N}\sum_{i=1}^{N}\varphi_i \tag{13}$$

We also reported the linear regression estimates with Driscoll–Kraay (DK) standard errors while conducting a robustness checks for multicollinearity through the variance inflation factor (VIF) as reported in Table 9 in the Appendix. A combination of these approaches has been noted to be very efficient in producing robust estimates especially when cross-sectional dependence issues have to be accommodated in a panel analysis (Zhang and Lin, 2012; Le and Ozturk, 2020).

4. RESULTS AND DISCUSSION

4.1. Preliminary Tests Results

The author present summary statistics and correlation matrix of the variables in table 2. It can be observed that, income has the highest mean of 3601.158 million dollars per year, minimum of 462.254 million dollars per year and a maximum of 20532.95 million dollars per year whiles, consumption-based CO_2 pollution has the lowest mean of 1.950 metric tons per year, minimum of 0.008 metric tons per year and maximum of 11.203 11.203 metric tons per year. From the correlation, there is a positive substantial connection among all the factors expect urban population which although have positive relationship but not significant.

TABLE 2. Summary Statistics and Correction analysis

	CCO_2	**Y**	**NRR**	**FDI**	**UP**
Mean	1.950	3601.158	45.815	5.914	50.450
Median	0.726	2254.510	32.096	2.049	64.726
Maximum	11.203	20532.95	99.977	161.823	98.303
Minimum	0.008	462.254	0.110	1.703	0.0589
Std. Dev.	2.550	3780.933	35.918	14.784	34.381
Skewness	1.902	2.045	0.419	5.749	-0.337
Kurtosis	5.749	6.908	1.591	45.497	1.410
Jarque-Bera	371.907a	540.136a	45.338a	32708.21a	50.294a

Probability	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	405	405	405	405	405
LnCCO2	1				
lnY	0.892a	1			
lnNRR	0.478a	0.245a	1		
FDI	0.097b	0.128a	-0.152a	1	
lnUP	0.010	-0.251a	0.611a	-0.296a	1

Note a=0.01, b=0.05 and c=0.01

<u>Table 3. Cross-sectional dependency (CD) estimation outcome</u>

Model	**Pesaran (2007) CD Test**	**Pesaran (2015) LM Test**	**Breusch and Pagan (1980) LM Test**
$lnCCO_2$= f(lnY, lnNRR, FDI, lnUP)	2.700a	-1.684a	1545.62a
p-value	(0.006)	(0.002)	(0.000)

Note a=0.01, b=0.05 and c=0.01

A look at the results in Table 3 shows that the conducted CD test provided evidence of cross-sectional dependence in the panel analysis since there is sufficient proof to reject the null hypothesis that support an independent cross-section for the variables in the panel study. Hence, the second generation CIPS unit root test of Pesaran (2007) was reported for the variables in the study in Table 4 before providing a panel cointegration report as shown in Table 5. The unit root results with regards to CIPS in Table 4 affirms that the factors are stationary at first difference expect FDI and urbanization which is has stationarity at level.

Table 4. Unit Root estimation

Variables	**CIPS**				
	I(0)		**I(1)**		
	C	**C&T**	**C**	**C&T**	**Result**
$lnCCO_2$	-2.747	-2.870	-5.650a	-5.835a	I(1)
lnY	-2.508	-2.234	-3.591a	-3.886a	I(1)
lnNRR	-1.544	-2.238	-4.309a	-4.655a	I(1)
FDI	-2.824a	-3.320a	-	-	I(0)
lnUP	-2.763b	-2.961b	-	-	I(0)

Note a=0.01, b=0.05 and c=0.01

Table 5. Westerlund (2007) Cointegration Test

Statistics	Value	p-value
Gτ	-2.232c	(0.070)
Gα	-1.629a	(0.000)
Pτ	-9.574a	(0.005)
Pα	-3.073b	(0.046)

Note a=0.01, b=0.05 and c=0.01

The Westerlund (2007) Cointegration technique outcome in Table 5 establishes a long-run association for the elements in the panel analysis. The conclusion was supported by the evidence for the rejection of the null hypothesis based on the significance of the obtained group statistics and the panel statistics. Thus, the appropriate panel techniques were applied to obtain the long-run cointegrating coefficients

4.2. Panel Estimation Techniques.

From Table 7, the adopted estimators namely the AMG, the CCEMG, and the Driscoll-Kraay approach produced relatively close results on the average, with little difference that are only observed in terms of the magnitudes of estimated coefficients and their corresponding level of statistical significance. From the analysis, economic growth shown a positive significant. This clearly showed the existence of environmental degradation across the oil production Sub-Sahara Africa countries because of economic activities in the countries targeting economic growth. It therefore supports the notion that emerging/developing countries are economically progressing at the expense of their ecological performance. The outcome is in agreement with the outcomes by (Charfeddine, 2017; Omri et al., 2015; Galli, 2015, Gyamfi et al 2021a).

Moreover, the outcome obtain from natural resources shows a positive and significant relationship with ecological degradation for consumption-based CO_2 pollution. This affirms that, natural resources encourages pollutions within the oil production Sub-Sahara Africa economics which confirms the analysis of Amed et al. (2020), Hassan et al. (2019) Gyamfi et al (2021b). It can be observed that these nations have an amount of income to be used for export and internal usage. This results, nevertheless, affirms the idea that the extraction of natural resources within those nations has never become effective. Excess dependency on natural resources leads to the depletion of bio-capacity, given that resources cannot be regenerated. Also, the use and development of agricultural materials promotes deforestation which boosts pollutant in view of the strategically important of the oil production Sub-Sahara Africa economies. In addition, some of nations utilize their natural resources (coal, petroleum & gas) to satisfy their energy demands. It was suggested that the availability of resources would allow a nation independent by decreasing imports of energy and relying on internal energy production with lower pollution (Ahmed et al. 2020).

Moreover, there is a positive association regarding foreign direct investment as well as consumption-based CO_2 emission for the oil production Sub-Sahara Africa countries. This negates the facts that oil resources could be a deciding factor for the movement of foreign direct investments. Hence, the same trend is witnessed across the region irrespective of where oil rent is domiciled. Most probably, there are other factors that sees to the attraction of FDI such as, access to cheap labor, closeness to market and less rigid policies in curtailing the excesses of the foreign investors. This is a pointer that Sub-Saharan region of African countries are still progressing in their economic activities and growth with neglect to the quality of their environment. This justified the view of some advocates against the positive impact of FDI especially on the sustainability of developing countries. This finding is in supports of pollution haven hypothesis (PHH) and supports the findings Shahbaz et al. 2015; Solarin et al. 2017; Gorus and Aslan 2019; Sarkodie and Strezov 2019 Udemba 2020b for India).

Nevertheless, the author also found that urbanization aggravates consumption-based CO_2 emission for the oil production Sub-Sahara Africa countries. This embraces the results for Salahuddin et al. (2019) and Charfeddine (2017). Urbanization boosts the economy and expands the density of towns that have minimal resources. However, Urbanization raises desire for transportation, lodging and household equipment and so on (Lin and Du 2015). Given that the energy used by E7 is largely non-renewable, pollutant are projected to increase. The rise in urban citizens in E7 could lead to a better development path, along with energy usage, garbage production and low energy utilization.

Table 7. AMG, CCEMG and Driscoll-Kraay result.

	lnY	**lnNRR**	**FDI**	**lnUP**	**R^2**	**Wald test**	**No. group**	**No. Obs.**
AMG	0.668a	0.015b	0.015b	0.159c		28.59c	15	405
P-value	(0.004)	(0.033)	(0.019)	(0.086)		(0.0722)		
CCEMG	0.971a	0.197c	0.008c	0.617b		28.51c	15	405
P-value	(0.007)	(0.051)	(0.092)	(0.048)		(0.0745)		

Driscoll-Kraay	1.133a	0.230a	0.018b	0.023c	0.8674	1099.40a	15	405
P-value	(0.000)	(0.000)	(0.018)	(0.067)		(0.000)		

Note: a=0.01, b=0.05 and c=0.01

4.3. DH Granger causality evidence

The Dumitrescu and Hurlin (2012) Granger causality technique was utilized for the causality analysis for the panel variables. Causality analysis for this study would help in showing the true direction of causation among the understudied variables as seen in the procedures in extant studies (Shahbaz et al. 2018; Bekun et al. 2019; Gyamfi et al 2021; Gyamfi et al 2020; Alola et al. 2019).

From the analysis it was observed that, there is a feedback causal association among urbanization and consumption-based CO_2 pollution for the oil production Sub-Sahara Africa countries. On the other hand, a one-way causal relationship is observed between consumption-based CO_2 emission and factors such as income, natural resources and foreign direct investment.

Table 8. Dumitrescu and Hurlin Causality Analysis

Null Hypothesis:	W-Statistic	p-value	Causal Remarks
$lnY \rightarrow lnCCO_2$	9.222a	(0.0001)	One-way
$lnCCO_2 \rightarrow lnY$	0.692	(0.5008)	
$lnNRR \rightarrow lnCCO_2$	0.157	(0.8542)	One-way
$lnCCO_2 \rightarrow lnNRR$	2.677c	(0.0701)	
$FDI \rightarrow lnCCO_2$	11.673a	(1.E-05)	One-way
$lnCCO_2 \rightarrow FDI$	0.936	(0.3929)	
$lnUP \rightarrow lnCCO_2$	2.460c	(0.0868)	Feedback
$lnCCO_2 \rightarrow lnUP$	4.541b	(0.0113)	

Note a=0.01, b=0.05 and c=0.01

5. Conclusion remark and policy suggestion

Sub-Saharan African countries are known for rich natural and human resources capable of attracting prospective investors from across the globe. With the current concern over the increasing climate change which are associated with different factors, divided views have emerged with regards to the influence of foreign direct investment and natural resources on climate change through direct impact on environment. Some scholars support positive effect of foreign direct investment and natural resources, while others are averse about the positive impact. These two strong oppositions have paved way for the emergency of two hypothesis supporting negative impact (Pollution haven hypothesis) and positive impact (Pollution halo hypothesis) respectively. Bearing in mind the likelihood of finding negative impact of FDI and natural resources on the ecology of the selected countries, we opined that pollution haven hypothesis is expected to be revealed in the case of the oil production Sub-Sahara Africa countries from 1990 to 2018.

Scientific approaches such as Pesaran (2015) LM test, Pesaran (2007) CD and Breusch-Pagan (1980) LM test to evaluate for cross-sectional dependence as well as Pesaran (2007) panel unit root test to evaluate the integration features of variables were utilized. We then utilize Westerlund (2007) test to analyze the long-run equilibrium among variables. To evaluate the long-run coefficients of the variables, the Augmented Mean Group (AMG), the advanced Common Correlated Effect Mean Group (CCEMG) panel estimator and the Driscoll–Kraay (DK) OLS techniques were utilized. There was a uniform outcomes from all the estimators showing, a positive connection among all the variables (natural resource, FDI, income and urbanization) and consumption-based carbon pollution. The outcome confirmed a pollutant haven hypotheses for the oil production Sub-Sahara Africa countries. A robust check was done with granger causality and the findings as mentioned under empirical discussion section give credence to the findings from the techniques used especially with interative variables, hence, both natural resources and FDI Granger causing environment in one way. However, urbanization had feedback causality with consumption-based carbon pollution whiles income had a one-way causality with consumption-based carbon pollution.

After establishing the positive effects of FDI, natural resources, economic advancement and urbanization on the ecological quality (consumption-based carbon emissions) of selected oil producing countries in Sub-Saharan Africa, the policy recommendation will be to frame ecological regulation strategies that rein in the abuses of power of foreign investors. Such measures could include the imposition of a carbon tax and a pollution limit, with the possibility of a fine for any firm that violates the ceiling regulation or the imposition of stricter penalties such as compulsory closure or the revocation of the firm's operating license by the authorities. Establishing an ecological enforcement agency with headquarters in each of the nations concerned and tasked with the responsibility of ensuring ecological performance is another sound strategy. The governments of the selected countries must develop a clear long-term plan for achieving the sustainable development target by 2030. This will instill a sense of responsibility in succeeding authorities to maintain a high standard of environmental sustainability.

Moreover, Policy makers should pursue ecological legislation and encourage new customer inflows to use sustainable energy as their primary source of energy and to adopt sustainable manufacturing practices to reduce their reliance on depleting products from industrialized economies. Established investors must be encouraged to invest in renewable energy initiatives to strike a balance regarding stable economic advancement and the environment.

It can be concluded that the results of this analysis apply to other emerging nations that have similar policy conditions, including those not in the Sub-sub-Saharan Africa but emerging seven (E7), MINT countries, etc.

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Declarations

Availability of data and materials

The data for this present study are sourced from the World Development Indicators (https://data.worldbank.org/). The current data specific data can be made available upon request but all available and downloadable at the earlier mentioned database and weblink

Competing interests

I wish to disclose here that there are no potential conflicts of interest at any level of this study.

Funding

I hereby declare that there is no form of funding received for this study.

Authors' contributions

The author (Dr. Bright Akwasi Gyamfi) was responsible for the conceptual construction of the study's idea, handled the literature section, managed the data gathering, preliminary analysis and proofreading and manuscript editing.

Ethical Approval: Authors mentioned in the manuscript have agreed for authorship read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.

Consent to Participate: Note Applicable

Consent to Publish: Applicable

Acknowledgments

Author gratitude is extended to the prospective editor(s) and reviewers that will/have spared time to guide toward a successful publication.

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Yours truly,

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