THE NEXUS BETWEEN TRADE OPENNESS AND ENVIRONMENTAL QUALITY EVIDENCE FROM SUB-SAHARAN AFRICAN COUNTRIES

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Abstract

In the forefront of achieving environmental sustainability, many debates have been ganged against the side effects of free trade on the quality of the environment. Never the less, it is believed that human activities through international trade have a strong repercussion on the quality of the environment. The paper attempts to systematically examine the nexus between trade openness and environmental quality in sub-Saharan African countries. The study used a panel of 41 SSA member countries from 1996 to 2020, using panel data of 41 selected sub-Saharan African countries, and this relationship was illustrated using the system GMM technique. The findings show that free trade, population, and industrialisation are positively and strongly associated with environmental quality. Foreign direct investment and urbanisation are negatively and significantly correlated with environmental quality. To conclude, it was revealed that there is a significant trade-off between trade openness and environmental qualities, with implications for policy; the study recommends that there is a need for a rapid minimum environmental policy that is compatible with local reality in order to make sure that the impact of free trade on environmental quality is mitigated. There is a need for Sub-Saharan African

governments to implement sound policies and provide a conducive environment for foreign and domestic investment. Finally, a well-designed and controlled urbanisation policy is needed to fight against environmental degradation. Such a policy entails empowering the rural population and developing rural areas to avoid the pressure on urban cities. To lessen the impact on the environment, the rural people need to be made aware of the need and offered alternate energy sources that are environmentally friendly.

Keywords: Trade Openness, Environmental Quality, Panel Data, Sub Saharan Africa

INTRODUCTION

In the fore front of achieving environmental sustainability many debates has been ganged against the side effects of free trade on the quality of environment. Never the less, it is believed that human activities through international trade has a strong repercussion on the quality of the environment, and the magnitude of these trading activities' impact on the environment depends on every economy in respect to its trading and environmental policy; however, even with growing worries and concerted efforts, environmental issues have only gotten worse in the last ten years, notably with the current worsening of climate change accompanied by primarily carbon-based pollution (Ugwu *et al.,* 2020). Mankind and the environment are closely related, just as trade volume are correlated with environmental quality given that people work hard to preserve the environment and its natural resources (World Health Organisation (WHO), 2002).

Also, Sub-Saharan African countries are more integrated internationally are vulnerable to free trade consequences such as high CO_2 emissions from foreign direct investment and massive pressures on the quality of the environment due to weak institutional policies in these countries; without doubt, the significant pressure of these free trade activities on the environment has detrimentally affected the quality of the ecosystem (Sandholtz & Gray, 2003; Gatti, 2004). In fact, corruption hinders economic activity by skewing the effective use of resources and driving up expenses. Even if the increase in international trade may cause environmental problems by causing changes in the production structure and environmental conditions in the race to provide competitive advantage among countries, it is important to maintain the regulatory laws consistently in order to reduce any possible negative effects.

Although many scholars argue that sub-Saharan African countries have witnessed a drastically increased in international trade in the past few years, which has contributed to their economic progress and been beneficial to them in terms of increasing their standard of living through the consumption of a variety of goods and services from abroad, some authors argue

that despite these benefits from free trade, there are also serious environmental challenges as these countries become integrated in free trade, for instance, externality in terms of environmental pollution from foreign direct investment. In this sense, Africa remains quite vulnerable to climate change, even though most of its countries create fewer greenhouse gases than those on other continents (Edmond As a result, for sub-Saharan African nations to have sustainable development growth, their levels of environmental pollution must be low or nonexistent, based on their institutional structure and amount of economic activity (Byaro & Kinyondo, 2020). Trade, financial development, industrialisation, and urbanisation can all aid in the development of sub-Saharan African nations in a more sustainable way.

More so, it is argued that free trade detrimentally influences the quality of sub-Saharan African countries ecosystems. While some of them come to the agreement that free commerce across sub-Saharan African countries borders negatively influences the state of the environment, others come to the conclusion that democracy and environmental quality are positively associated. Based on these arguments, the scale, technical, and compositional consequences of trade openness on the environment are broken down by Grossman and Krueger (1995), as scalar increases in economic activity have negative consequences on the environment, which are quantified by the scale effect of international trade. The technical consequence of revenue growth is the favorable environmental implications that make cleaner industrial methods necessary. The composition impact can be advantageous or detrimental to the quality of the environment since it monitors the economy's progress toward a more or less suitable productive structure (Grossman & Krueger, 1995).

According to Bekoe and Jalloh (2023), Copeland and Taylor (2004) on the same stand point illustrated that, due to scale effects, method effects, and composition effects, free trade has an impact on environmental quality. The scale effect demonstrates how improved market accessibility and economic growth cause an increase in pollutants entering the ecosystem, which has negative long- and short-term effects on environmental quality. Changes in the share of dirty products in GDP are the best indicators of the composition effect. Trade openness may reduce or increase CO_2 emissions, depending on whether a nation has a comparative advantage in clean or dirty industries. FDI inflows to underdeveloped countries may be seen as a means of transferring filthy industries there and raising pollution levels. However, FDI may open up access to improved technologies, which could help to significantly reduce pollution. The import of greener production methods that accompany trade liberalisation is referred to as the "technique effect." The interaction between these three effects creates an ambiguous overall effect depending on which effect is more potent and predominates over the others.

In other words, trade openness can have long-term consequences for the state of the environment by negatively affecting environmental conditions (Managi *et al.,* 2009). On the other hand, excessive industrialisation in developing nations could worsen working conditions, increase pollution and unchecked urbanisation, and lower standards of living (Grossman & Krueger, 1993; Levine & Rothman, 2006). Environmental pollution is a major issue in Sub-Saharan Africa countries due to the high rate of urbanisation, high taste to attain certain levels of economic growth (over 4%), industrialisation, and high dependence on foreign investment, increases in population, motorisation, and increased economic activity on the continent. Environmental deterioration is further exacerbated by rising energy consumption and a reliance on biomass-based fuels for lighting, heating, and cooking (United Nations Environment Programme (UNEP), 2016).

In this regard, Ngouhouo and Nchofoung (2021) contend that strong environmental governance is essential for the development of resilient nations. The relationship between environmental quality and economic development has been the subject of an increasing amount of research. Economists frequently summarize this relationship using the Environmental Kuznets Curve (EKC) theory, which postulates that CO_2 emissions rise with economic expansion up to a certain level of growth before this relationship becomes negative. According to Swaroop *et al.* (2008), environmentalists only succeed in their goals in countries with sound governance, suitable bureaucratic procedures, and a minimal level of bribery. That is, results for environmental quality are not just enhanced by sound environmental regulations. Rather, governance tools, international trade policies, and strong institutions are required. However, sub-Saharan African countries continue to suffer from weak environmental policies, leading to both massive impacts from foreign companies and domestic industries freely misusing the ecosystem with little concern for the environment's side effects since the environment laws are never enforced in these sub-Saharan African countries. Trade agreement policies are also not respected, which has harmed both the quality of the environment and the economies of these sub-Saharan African countries.

However, the necessity to safeguard biodiversity, human health, and economic activities has generally increased awareness of these environmental quality challenges in recent years amongst developing nations (Yameogo *et al.,* 2020). Also, compared to industrialised economies, carbon emissions tend to increase more quickly in developing nations, which negatively affects the ecosystem and, as a result, indirectly affects human health (Kuldasheva & Salahodjaev, 2022). With this regards several efforts has being undertaken on a global scale to reduce carbon dioxide (CO_2) emissions and use carbon in the economy sparingly following the fundamental objectives of 2030 agenda as far as the yardsticks of environmental qualities are

concerned, a particular emphasis should be put on issues like air quality, chemical safety, water, sanitation, and hygiene, as well as climate action (Harivelo & Harifidy, 2022)..

Couple with weak institutions, relax environmental regulation and poor trade policies, environmental hazards are more prone to occurring in developing countries, especially the poorest ones (Abeysekara *et al.*, 2023). Despite their best efforts in putting in place these environmental regulations, they still have to deal with the consequences of economic activities (poor agricultural productivity, increasing hunger, malnutrition, and disease and corruption). According to Abeysekara *et al.* (2023) most sub Saharan African countries economies are closely linked to climatically vulnerable industries like agriculture, rapid increase in population and urbanisation in order to further explain this susceptibility, more specifically, a number of additional factors can explain why these countries are vulnerable to climate change and couple with the fact that these sub Saharan African countries greatly relies on primary sectors which are sectors accompanied by high source of pollution to the environment (Liu *et al.,* 2022).

Therefore, trade openness raises questions regarding its influence on the quality of the environment, particularly in developing nations, of which Sub-Saharan countries are scarcely an exception. This is due to the desire of all countries to facilitate trade in order to spur economic growth. On the other hand, pollutant gases transcend borders. Trade networks suggest not just the interchange of goods but also the transmission of the environmental cost of their production. Although though each country should contribute to halting environmental degradation, emerging markets usually place a higher priority on economic growth through trade policy than improvements to environmental quality (Wang *et al.,* 2022). Also, in the front of environmental policy against environmental degradation, sub-Saharan African countries continue to suffer from weak environmental and trade policies, which have allowed massive environmental pollution as a result of trade openness activities that are usually carried out in these countries without taking environmental norms into special consideration, and most often the repercussions of trade openness activities on the quality of the ecosystem are felt in the time rather than an immediate effects (Eskander & Fankhauser, 2023).

Considering the significance of the aforementioned arguments for and against trade opening on environmental quality, the reason for this study was due to the fact that, despite the fact that Sub-Saharan African nations create fewer greenhouse gases, their environmental quality is still declining at an alarming rate, which was the impetus for this study. So, the aim of this study was to establish the relationship between trade openness and environmental quality with regard to Sub-Saharan African countries without compromising other criteria that might influence the quality of the environment, such as urbanisation, foreign investors, population,

industrialisation, and gross domestic product per capita, in order to identify the existence of this contradiction or paradox.

LITERATURE REVIEW

Pham (2016) claims that trade openness is accomplished through lowering trade barriers and is calculated as the GDP to the total of exports and imports. To take into consideration the direct impacts of trade liberalisation on environmental quality, trade openness is introduced to the Pollution Haven Hypothesis (PHH) theory. According to the Pollution Haven Hypothesis (PHH) theory, companies who manufacture dirty goods in industrialised countries with severe environmental rules will relocate to underdeveloped countries with fewer constraints. So, depending on the stages of economic development, the coefficient of trade openness may have a favorable or negative impact (Pham, 2016).

The term "environmental quality" refers to a group of environmental characteristics and aspects that, either locally or internationally, have an effect on people and other living things. It is a method of assessing how well an environment is doing in regard to the needs of one or more species and/or any human needs or goals (Johnson *et al.,* 1997). The term "environmental quality" refers to a wide range of aspects of the built environment as well as the natural environment, including noise levels, air quality, and water quality, as well as any potential effects that these aspects may have on physical and mental health as a result of human activity (Johnson *et al.,* 1998).). According to Marsooli *et al.* (2019), these factors include things like air, water, soil, and sound/noise that can have a beneficial or bad impact on a person.

Daniel *et al.* (2022) examine ecological footprint measurements of 23 Sub-Saharan African countries' trade openness and foreign direct investment (FDI) flows. Cross-sectional dependence, serial correlation, heteroscedasticity, and the presence of cointegrating correlations have all been checked for in the 1990-2015 panel data. It utilises the Feasible Generalized Least Square approach to get accurate and reliable coefficient estimates. The endogeneity of trade openness and income is also addressed through the use of instrumental variable approaches. According to the findings, the ecological footprint of consumption per person falls when trade openness rises but it rises as direct investment from abroad rise.

Bright *et al.* (2022) Examine the impact of trade, economic expansion, availability of natural resources, the use of clean energy, and urbanisation on consumption-based carbon emissions (CCO_2) for economies in Sub-Saharan Africa (SSA) from 1990 to 2018. The study used second-generation methodologies, such as CS-ARDL, and found that trade; money, natural resources, and urbanisation all have a favorable effect on CCO_2 emissions. The combination of commerce and income also contributes to the rise in CCO_2 emissions. Moreover,

renewable energy has a negative effect on CCO_2 emissions. A one-way causation was found from natural resource rent to CCO_2 emission, according to the causality analysis, whereas there is feedback causality between CCO_2 emissions and income, clean energy, and urbanisation.

Ahmed et al. (2019) analyse the nonlinear relation between urbanisation and CO_2 emission from 1971 to 2014 in Indonesia. Their findings revealed that urbanisation and carbondioxides emission exhibit an inverse U-shape relationship between urbanisation and carbondioxides emission, their results show that carbondioxides decrease with an increase in urbanisation at decrease rate and increase CO_2 emission at an increase in the long run. Additionally, the study has verified the validity of the results using environmental degradation proxies. The results of the causality test show that economic growth, emissions, and energy intensity have a one-way causal relationship. Urbanisation and emissions also have a feedback relationship. Finally, a number of policy initiatives are suggested to enhance the environment without lowering the amount of urbanisation.

Çamkaya *et al.* (2022) examining the connections between carbon emissions, economic growth, energy consumption, foreign direct investments, and trade openness for Turkey, one may determine the veracity of the Pollution Haven Hypothesis in that country. The validity of the idea was investigated in Turkey between 1970 to 2018 using the ARDL technique. The findings confirm the long-term relevance of Turkey to the Pollution Haven Theory. Also, it was discovered that while negative shocks to growth and energy consumption had the opposite effect from positive shocks to trade openness and energy use, long-term increases in carbon emissions were the outcome of positive shocks.

Ahmed *et al.* (2022) the primary cause of anxiety in recent years has been environmental degradation as a result of the harsh effects of climate change. This study utilised panel data of 55 nations in the Asia-Pacific area from 1995 to 2020 and applied an autoregressive distributed lag (ARDL) model to estimate the comprehensive impact of industrialisation and foreign direct investment on environmental degradation. Their finding show that environmental degradation continues to be on the rise as result of industrialisation and foreign direct investment, their findings further revealed that the impact of foreign direct investment on environmental degradation was positive, however the impact was moderate and the study was supported by pollution heaven hypotheses and environmental Kuznets Curve theory (EKC) and the study recommends a strictly environmental management regulation.

METHODOLOGY

Using the panel data of 41 countries across four sub-regions of sub-Saharan Africa, the selection of the 41 countries is based on the availability of data on relevant variables in

connection with the study. Data was available for all countries from 1996 to 2020, making this a 24-year study, and the data for the study was selected from world development indicators based on 2020 database. The system GMM was used to demonstrate the nexus between trade openness and environmental quality. We created a model with trade openness as the main independent variable and environmental quality as the primary dependent variable, proxies for greenhouse gas. The economic functional model is given as follows:

Environmental quality = f (Trade Openness $_t$, other control Variables $_t$) …………. (Equation 1)

More specifically, the econometric model is specified in equation 2 below:

$ghg_{it} = \beta 0 + \beta_1 ghg_{it-1} + \beta_2 lntop_{it} + \beta_3 lnfdi_{it} + \beta_4 lngdppc_{it} + \beta_5 lnpop_{it} + \beta_6 lnurb_{it} + \beta_7 lnind_{it} + \varepsilon_t$…………..………….... (Equation 2)

Where:

ghg= greenhouse gasses; ghg_{it-1} = lagged level of greenhouse gasses; lnopen = log of trade openness. Trade openness is measured by exports plus imports divided by GDP; lnfdi= log of Foreign Direct Investment; lngdppc= log of gross domestic product per capital; lnpop= log of population; lnurb= log of urbanisation and lnind = log of industrialisation. The β_0 is a constant term and β_1 to β_7 are estimated parameters in the model and ε_t is an error term.

In order to address the potential endogeneity bias, this study uses the Generalized Method of Moments (GMM) estimate approach created for dynamic panel data models. Based on an unbalanced panel of 41 sub-Saharan nations for the years 1996–2020, estimates are made. The above-listed elements of environmental quality are the dependent variables, and trade openness is the ultimate and key independent variable for this goal. The estimations also contain a variety of control factors, including foreign direct investment (FDI), urbanisation (URB), population (POP), and industry (IND). Most often, the agency in charge of gathering information is also lacking, and even when they do exist, they are frequently under-equipped, which means that the information they gather is too limited or truncated to be used in the way that would be most effective for taking data beyond the time frame of the current study. Therefore, the selected time frame for time series data is from 1996 to 2020 due to data availability constraints on the selected variables for this study.

RESULTS

Diagnostic Tests Results

To confirm that the data used in the model estimation are appropriate, unit root, and endogeneity, tests are conducted. Recall that the IPS unit roots test was conducted to determine the level of integration of the variables used for the study. Results of the stationarity test are summarised in table 1.

The IPS Unit Roots Test

In the combination of horizontal section data and time series data, which is the case with panel data, the stationarity of the series should be tested before performing econometric analysis (Baltagi, 2001). To investigate the statistical properties of the data, we started by checking the presence of a unit root. To this end, we applied the IPS Unit Roots Test (Im et al., 2003). The unit root test results show that the null hypothesis of a unit root can be rejected because all variables have no unit root, implying that series are stationary at level I(0).Therefore, we reject the null hypothesis for all the variables, implying that all the variables are stationary at level for at least one of the panels. Thus, the variables can be analyzed at level with little risk of generating spurious regression.

Table 1: Summary of IPS Unit Roots Test Results

Variables	Statistic (t-bar)	p-value	1% critical value	5% critical value	10% critical value	Decision
top	-4.9420	0.000	-	-	-	I(0)
GDP per capital	-3.5015	0.000	-1.820	-1.730	-1.690	I(0)
Pop g	-1.8334	0.0454	-1.820	-1.730	-1.690	I(0)
urb	-3.4230	0.000	-1.820	-1.730	-1.690	I(0)
ind	-5.4458	0.000	-1.820	-1.730	-1.690	I(0)
fdi	-3.1224	0.000	-1.820	-1.730	-1.690	I(0)

Descriptive Statistics and Correlation Analysis

Table 2 present the summary descriptive statistics of the variables of this paper between the periods 1996 to 2020. A total of 24 observations were considered. This depict the numbers of years for which the variables have been use (24) multiple by the number of countries (41). Table 2 also shows the different statistical fact about data such as mean, standard deviation and median.

Table 2: Descriptive Statistics for Variables

Variable	Mean	Std. Dev.	Min	Max
Top	69.21001	34.78102	.7846308	225.0231
Fdi	4.079865	8.101796	-11.19897	161.8237
Gdppc	2181.868	2866.652	3.290291	16438.64
Pop	1.92e+07	2.87e+07	76417	2.06e+08
Urb	39.35926	15.79345	7.412	90.092
Ind	25.60674	12.81537	4.555926	84.3492
Ghg	33592.52	43518.89	300	311450
Number of Countries	41	41	14	41

Before the model coefficient results, descriptive statistic is given at Table 2. Average trade openness of the countries analyzed in the study is 69.21001, foreign direct investment is 4.079865, gross domestic per capital is 4.079865, population is 1.92e+07, urbanisation is 39.35926, industrialisation is 25.60674 and greenhouse gases is 33592.52 as environmental quality level.

Pairwise correlation

Table 3: Summary of Pairwise correlation Marix Table for the Variables

	lnghg	top	fdi	lngdppc	Lnpop	Urb	ind
lnghg	1.0000						
Top	-0.3598	1.0000					
	(0.0000)						
Fdi	-0.0839	0.3942	1.0000				
	(0.0100)	(0.0000)					
lngdppc	-0.2408	0.5216	0.0902	1.0000			
	0.0000	0.0000	0.0038				
lnpop	**0.8693**	-0.5590	-0.1680	-0.4504	1.0000		
	0.0000	0.0000	0.0000	0.0000			
Urb	-0.1227	0.3712	0.1272	0.5946	-0.2959	1.0000	
	0.0002	0.0000	0.0000	0.0000	0.0000		
Ind	**0.1176**	0.4274	0.0909	0.3842	-0.0919	0.4970	1.0000
	0.0004	0.0000	0.0040	0.0000	0.0036	0.0000	

Table 3 above give a pairwise correlation matrix for the variables indicate that only two of independent variables population and industries had a positive relationship with the dependent variable. Furthermore, we notice very weak correlation amongst some of the independent variables which show an indication of absent of multicollinearity problem amongst such variables. However, in order to a conclusive answer whether multicollinearity exists or not, we carry a formal test of multicollinearity.

Empirical Analysis

This section is devoted to the interpretation of empirical findings of the effects trade openness on environmental quality. Found in the table 4 are the fixed effects (FE) estimators without joint effect of trade openness and environmental quality (equation 1). The study conducted a system GMM which results are reported in table 4.

Table 4: The effects trade openness on environmental quality

Variables	(1) Random Effect	(2) Fixed Effect	(3) System GMM
TOP	0.000800**	0.000786**	0.0154**
	(0.000318)	(0.000318)	(0.00620)
FDI	0.000344	0.000281	-0.0173*
	(0.000991)	(0.000990)	(0.0102)
LNGDPPC	0.319***	0.319***	-0.0584
	(0.0271)	(0.0288)	(0.0582)
LNPOP	0.944***	0.987***	0.968***
	(0.0369)	(0.0507)	(0.0719)
URB	-0.00794***	-0.0102***	-0.00871
	(0.00199)	(0.00241)	(0.00740)
IND	0.000568	0.000120	0.0420*
	(0.00101)	(0.00102)	(0.0227)
Constant	-7.267***	-7.905***	-7.005***
	(0.550)	(0.700)	(1.370)
Observations	909	909	886
R-squared		0.654	
Number of country	41	41	41

Notes : *The Independent variables are as follows : lnopen = log of trade openness. Trade openness is measured by exports plus imports divided by GDP; lnfdi= log of Foreign Direct Investment; lngdppc= log of gross domestic per capital; lnpop= log of population; lnurb= log of urbanisation; lnind = log of industrialisation.*
*Each cell contains the regression coefficients and the standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$*

As shown in Table 4, trade openness positively affects greenhouse gases, indicating that trade openness has a positive and significant impact on greenhouse gases. By implication, a unit increase in trade openness reduces environmental quality as a result of its increased environmental proxies (greenhouse gases). This shows that since most sub-Saharan African countries have integrated internationally and their quest for economic growth puts so much pressure on the environment, which indirectly affects the quality of these countries ecosystems by the increase of greenhouse gases, and since these countries have weak environmental policies, weak trade policies, and corruption in their trade policies, trade openness heavily affects the environment negatively. The finding was similar to that in the work of Daniel *et al.* (2022). Their findings showed that trade openness rises in tandem with foreign direct investment inflows, which lowers the ecological footprint of consumption per person. The results also support the presence of an inverted-U relationship between ecological footprint and GDP per capita. However, this outcome was different from Mutascu's (2018) discovery, and the key

findings show that trade openness and gas emissions do not move together frequently, supporting the neutral hypothesis in the medium term.

The finding further revealed that foreign direct investment has a negative and significant effect on environmental quality when considering environmental quality proxies in model (3). This shows that an increase in foreign direct investment (FDI) by one unit will lead to a decrease in environmental quality by 0.0173 everything being equal, and by implication, an increase in foreign direct investment will decrease environmental quality, which is very much in line with our expectation that foreign direct investment has a detrimental or negative effect on the quality of the environment. However, this negative impact on environment quality is accountable to the fact that most of these countries have weak institutions and relaxed environmental policies, which allowed foreign countries with low pollution abatement to continue trading in these countries. Coupled with high levels of corruption in these countries, most of the trade policies put in place are never respected since the stakeholder in charge of ensuring that trade policies put in place to protect the ecosystem are respected had been corrupted in one way or another. This finding was in line with the result of Ahmed *et al.* (2022). Their research revealed that foreign direct investments negatively affects the ecosystem and with an increase gas pollutants Carbon dioxide and Methane emissions. Therefore, this study makes the case that stringent enforcing of ecosystem.

Moreover, the gross domestic product per capita has negative and insignificant effects on environmental quality in model (3), but in models (1) and (2), the findings revealed that an increase in GDP per capita by one percent will bring about a 0.01-point increase in the country's greenhouse gas index, everything else held constant. This justified the fact that most sub-Saharan African countries GDP growth rate has an inverse effect on environmental quality considering what it proxies. The result was in line with the results of Chebbi *et al.* (2011), they investigated the relationship between trade openness, real GDP, and CO_2 emissions in Tunisia between 1961 and 2004 and found that, both in the short- and long-term, trade openness has a favorable direct impact on CO_2 emissions. The GMM method was used to analyze the data, and the results showed that LGDPPC is negative (-0.0584), indicating that economic growth has a negative effect on the environmental quality index, which serves as a proxy for greenhouse gases.

The population coefficient is positive (0.944, 0.987, and 0.968) for the three models, respectively, and significant at the 1% level. In this effect, results from Table 1 show that an increase in environmental quality considering its proxies is compatible with an increase in population and was found to exert effects on the environment that are both favorable and significantly negative to the sub-Saharan countries selected. This is due to the fact that, over the

past few decades, sub-Saharan African countries have witnessed a rapid increase in their populations, which has exerted a large pressure on the ecosystem as a result of increased human activities and a high demand for land for agriculture since the majority of these populations depend on agriculture as a means of livelihood. Most of these populations largely depend on biomass as a source of fuel, which, with the passage of time, has greater effects on the environment's quality as these activities, as a result of the increase in population, have a negative effect on the environment. Also, the result indicates that urbanisation significantly reduces environmental quality in all three model scenarios. In fact, results from Table 4 show that an increase in environmental quality considering its proxies is compatible with an increase in urbanisation since both were found to exert a negative and significant effect on the environmental quality of the sub-Saharan countries selected, this as a result of the fact that an increase in urbanisation means compromising the natural environment, that is, urbanisation comes with an increase in the destruction of the natural environment, which at the end has a large repercussion on the ecosystem. The study was similar to the findings of Ahmed *et al.* (2019) their results show that, urbanisation increases CO_2 emissions initially, but at a certain point, it reduces emissions.

Finally, the coefficient of industrial is positive (0.000568) and statistically insignificant at 1% level which signifies that industrial increase environmental quality index significantly in selected sub Saharan Africa and the findings were consistent with fixed effect result. Similarly, going by system GMM estimation industrial coefficient was found to be positive (0.0420) and significant at 10%. By implication, an increase in industrial activity caused an increase in environmental quality proxies for greenhouse gases. The outcome was comparable to that of Ahmed *et al.* (2022) their finding show that environmental degradation continues to on the rise as result of industrialisation and foreign direct investment, their findings further revealed that the impact of foreign direct investment on environmental degradation was positive, however the impact was moderate.

The values of R-square at the bottom of the table indicate that 65.4% of variation in of changes in environmental quality is explained by the change of trade openness, foreign direct investment, gross domestic per capital, population, urbanisation and industrialisation.

CONCLUSION AND POLICY IMPLICATIONS

Today, it is evident that nations compete alongside business entities. The goal of this study was to analyse the relationships between trade openness and environmental quality. The Generalized Method of Moments was used to analyse how trade openness affects environmental quality. The study's data, which covers 41 sub-Saharan African nations from

1996 to 2020, was compiled from a variety of sources. The results of the data analysis reveal that trade openness has a significant effect on environmental quality when considering the proxies used for this study, but reduces environmental quality by either reducing gross domestic product per capita or increasing greenhouse gas emissions. Furthermore, results also indicate that there is a significant trade-off between free trade in sub-Saharan African countries and environmental qualities, as trade openness activities negatively affect the quality of the environment. The results further reveal that the levels of urbanisation, industrialisation, population, and foreign direct investment are significant yardsticks of environmental quality in sub-Saharan African countries, moreover, given the fact that this study was limited only to 41 sub-Saharan African nations and time series data from 1996 to 2020 and did not include other regions, generation using the findings has become difficult. In terms of policy implications, the paper recommends that policymakers, government officials concerned with environmental regulation, and other stakeholders in sub-Saharan African countries put in place strong laws protecting the environment from massive pollution from trade openness. This is possible if political meddling and corruption are avoided in institutions and programs that are focused on environmental quality. This will ensure that foreign direct investors, especially foreign companies with heavy pollutants in the environment, adopt technologies that do not harm environmental quality in sub-Saharan Africa countries. As for the impact of home industries impacts on the ecosystem, the study recommends that governments and other stakeholders in sub-Saharan African nations develop policies that encourage home investment in order to raise environmental quality. This is possible if governments and other stakeholders work to create a more welcoming business environment in sub-Saharan African nations, for example, by encouraging companies to use materials that are easily biodegradable. By doing so, domestic investments will increase and the condition of the environment in sub-Saharan African nations will improve. Finally, a well-designed and controlled urbanisation policy is needed to fight against environmental degradation. Such a policy entails empowering the rural population and developing rural areas to avoid the pressure on urban cities. The rural population should be sensitised, and alternative sources of energy should be proposed to them in order to maintained environmental sustainability. In terms of the potential for additional research, this article suggests that, a comparative analysis could be done between the non sub Sahara Africa countries and the sub Sahara Africa countries on the nexus between trade openness and environmental quality while incorporating others variables such as institutional quality and corruption.

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