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Environment challenges in Africa: further dimensions to the trade, MNCs and energy debate

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Abstract

Purpose – The purpose of this paper is to examine the linkage between environmental challenges, multinational corporations (MNCs) activities, trade and energy in Africa; and further elaborate on the role of institutions, as an intervening variable.

Design/methodology/approach – In this study, the authors extended the Environmental Kuznets Curve (EKC) model by including indicators of the presence of MNCs, trade and energy in the basic EKC model that has measures of environmental pollution (CO_2), economic growth (gross domestic product per capita) and its squared value. The role of institutions was also considered and included as an inter-mediating variable. This model was tested on a sample of 27 African countries, for the period 1996-2010. The systems GMM was applied for the empirical analysis. This approach was aimed at circumventing the possibility of reverse causality and endogenous explanatory variables-such as institutions.

Findings – Trade and MNCs' activities may not have much contemporaneous impact on the environment. However, their lagged values have adverse and significant influence on the current values of environmental challenge. This implies that environmental policies regarding trade and MNCs require time response lag. Energy was significant only at contemporaneous value but not at its lagged value. Institutional development helps to suppress the negative excesses (like pollution) from the activities of trade, MNCs and energy, and consequently reduce environmental pollution.

Originality/value – This paper included the role of institutions in the environmental pollution, trade, MNCs and energy debate. Empirical studies in this regard have inadvertently excluded this variable, but have, at best, included it as part of policy recommendations.

Keywords Africa, Energy, MNCs, Environmental challenges, Environmental pollution, Trade

Paper type Research paper

1. Introduction

Environmental challenges include the changes in climatic conditions, caused by hazardous atmospheric pollutions such as green-house gas (GHG) emissions. The resultant impacts

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such as extreme weather conditions and drought, are felt by households especially those that are impoverished, who do not have the capacity for adaptation. Consequently, countries' public policy agenda have focused on adopting strategies to mitigate the rising consequences. Some of these policies include: levies on carbon emissions, emphasizing green economy and green growth, low carbon development and price adjustment of bio-fuels as a disincentive for vehicular fuel consumption (Resnick *et al.*, 2012).

African countries are lagging behind in taking steps to protect their environment due to weak institutional framework (Osabuohien *et al.*, 2013). This can be deduced from the series of oil spillage from explorations of multinationals, flaring of gas and other forms of toxic gaseous discharges that are persistent in a number of African countries. It is therefore not surprising that there is a rising trend in the incidences of environmental challenges recorded in many Africa countries. Predictions from the Intergovernmental Panel on Climate Change (2007) reveal that the rising environmental changes in Africa will result to 50 per cent reduction in rain-fed agricultural output by 2020.

Globalization has enhanced boundless relationship across countries, which includes international trade and foreign capital flow. Similarly, the productivity of the manufacturing sector of countries, to meet up with the demand for trade and internal consumption, will require energy consumption particularly electricity, which being used by most appliances. These components (trade, energy and multinational corporations (MNCs) inflow, simply christened tripod) are crucial for economic growth and development (Osabuohien, 2007; Halicioglu, 2009). For instance, Hammouda, Geda and Karingi (2007) and Osabuohien (2007) have observed that trade competitiveness of African countries in the world market is required for her sustainable growth and development. This is because trade contributes to foreign exchange valuation, employment and national income. Focusing on MNCs inflow, Ahmed *et al.* (2011) emphasized the need for the inflow of foreign investment for enhanced employment, manufacturing sector development, technology spill-over and market expansions, among others. Energy also contributes to national income because it enhances industrial production and development (Altman *et al.*, 2008).

In the light of the above, there is a growing consensus that environmental pollution, in the form of carbon emissions, can be traceable to these components (the tripod) of growth and development (Resnick *et al.*, 2012). This implies that the tripod affect the environment through emissions that stem from their engagements: emissions from the transportation of goods for trade, emissions from industrial activities that is enhanced by energy and emissions from natural resource exploration by MNCs. To the extent that the tripod are relevant for economic progress, their impact on the environment cannot be neglected. It is therefore essential to provide empirical analysis on how the adverse consequences from their activities can be curtailed in Africa, despite their immense benefits. The role of institutional quality in this regards is emphasized in the present study.

African countries have lagged behind other regions in terms of broad measures of formal institutions. Despite this, their macroeconomic policies include improving their attractiveness to foreign capital and trade competitiveness. For instance, in 2000, the United Nations Millennium Declaration clearly points out that African countries require an increase in the volume of foreign capital flow for a speedy accomplishment of the Millennium Development Goals by at least half in 2015. Likewise, the recounting trade protocols and agreement signed by African countries indicate their desire to improve their trade competitiveness and outcomes. A vivid example in this regard is the African Growth and Opportunity Act signed in 2000 to strengthen the trade relationship between the USA and eligible African countries (Schaefer *et al.*, 2013). Other agreements include the Forum on China-Africa Cooperation, the Economic Partnership Agreements between European Union countries and the African, Caribbean and Pacific group of states. These leave an empirical concern on how African countries can effectively manage the adverse effect from the growth of these development "reagents" (*tripod*) through improving their institutional framework. This is owing to the fact that institutions provide guidelines and frameworks for economic actors in the society. The above also follow the submissions of institutional economists (e.g. North, 1991; Osabuohien and Efobi, 2013) that adequate institution is required to protect the society and economic agents from any form of hazards.

The remainder of this study encapsulates the background information followed by a review of literature. The method of analysis and data description are reported in Section 4. Section 5 discusses the empirical results while Section 6 concludes.

2. The tripod and environmental challenges in Africa

African countries have witnessed increased contribution of trade, energy and MNCs inflow to their economic growth and development. As evidenced in Table I, trade contributes more than 50 per cent of the gross domestic products (GDP) in Africa. Specifically, the value ranged from 53.16 to 79.78 per cent in the period 1971-2012. Compared to other regions of the world, Africa is only next to Middle East and North Africa (MENA) that has more than 63 per cent of trade to GDP within the period under consideration.

Concerning MNCs inflow, Table I reveals that Africa witnessed a gargantuan increase as the contribution of MNCs inflow to GDP increased by about 310 per cent between 1971-1980 and 2001-2010 even more than that for the period 2011-2012. The contribution of MNCs inflow in Africa was the highest in the period 1971-1980, compared to other regions of the world. The value reduced in the period 1981-1990 and 1991-1990, placing Africa at the bottom echelon. However in the period 2001-2010, Africa witnessed the second highest contribution of MNCs inflow around the world, after Europe and Central Asia; but has since returned to the highest position in recent period (2011-2012). Comparing the value to the world average, MNCs inflow into Africa was 27 per cent more than the world average in the period 1971-1980; later reduced by 19.47 per cent in the period 2001-2010 but later recovered to the value of 46.67 per cent in the period 2011-2012.

Examining the trend of energy consumption in Africa, there has been a somewhat consistent rising as the value increased from 386.37 kwh per capita in 1971-1980 to 578.32 kwh per capita in 2001-2010. However, comparing the value for Africa with other regions of the world, Table II revealed that Africa has remained lower than other regions. Africa's value was many folds lower than that of the world average and about ten times lower than that of Europe and Central Asia, especially in 2001-2010. This is expected as the region has been unable to explore its natural resources for energy production. Also, the usage of nuclear and renewable energy is unpopular in SSA.

Africa's experience with environmental challenges, especially GHG pollution is quite worrisome. Table III presents some stylised facts using the measure of environmental challenges in relation to air pollution and GHG emissions. This form of GHG is regarded as the largest contributors to the share of total GHG in the world (World Bank, 2007). The carbon dioxide (CO_2) emissions emanate from the burning of fossil fuels, the manufacture of cement, consumption of solid, liquid, and gas fuels and gas flaring.

Table I. Trade and MNCs Inflow across the world

Regions	Trade 1971-1980	Trade 1981-1990	Trade 1991-2000	Trade 2001-2010	Trade 2011-2012[a]	MNCs inflow 1971-1980	MNCs inflow 1981-1990	MNCs inflow 1991-2000	MNCs inflow 2001-2010	MNCs inflow 2011-2012[a]
East Asia and Pacific	35.68	40.33	42.80	57.81	66.50	0.28	0.44	1.14	2.03	3.00
Europe and Central Asia	47.95	55.05	59.71	73.45	82.13	0.61	0.78	2.51	3.98	2.13
Latin America and Caribbean	26.83	31.18	39.14	47.77	52.32	0.73	0.75	2.45	2.80	3.05
Middle East North Africa	76.95	68.18	63.74	80.03	na	0.15	0.79	0.82	3.06	1.73
South Asia	15.96	18.45	25.93	40.64	52.73	0.03	0.09	0.51	1.60	1.57
Africa[b]	54.76	53.16	57.08	66.52	79.78	0.76	0.54	1.54	3.13	3.30
World	33.41	37.97	42.70	53.00	61.00	0.49	0.70	1.75	2.62	2.25

Notes: Trade computed as trade as % of GDP; MNCs inflow measured as foreign direct investment, net inflows as % of GDP. [a]Average for 2 years showing the most current period. na, not available. [b]Africa here comprises mainly Sub Saharan Africa (SSA) countries
Source: Authors' computation from World Bank (2012).

Table II.
Electric Power Consumption (kwh) per capita across the World[a]

Regions	1971-1980	1981-1990	1991-2000	2001-2010
East Asia and Pacific	596.55	866.29	1,379.28	2,445.72
Europe and Central Asia	na	505.38	4,777.59	5,876.09
Latin America and Caribbean	670.16	1,060.81	1,382.16	1,918.89
Middle East North Africa	436.02	973.97	1,439.75	2,326.62
South Asia	105.43	182.51	312.32	470.83
Africa[b]	386.37	504.39	496.57	578.32
World	1,406.01	1,751.90	2,214.10	2,901.90

Notes: Electric power consumption in kilowatt hour (kwh) per capita is used as a measure for energy consumption measured due to the fact that it is used my most appliances; and data other forms of energy consumption are not available for many African countries. na, not available. [a]The period 2011 and 2012 was not included because data were not available for the regions. [b]Africa here comprises mainly Sub Saharan Africa (SSA) countries
Source: Authors' computation from World Bank (2012)

Table III.
CO_2 Emissions (kt) as percentage contribution to the world CO_2 emission[a]

Regions	1971-1980	1981-1990	1991-2000	2001-2010
East Asia and Pacific	15.65	19.52	25.55	30.84
Europe and Central Asia	na	na	29.71	23.77
Latin America and Caribbean	4.00	4.66	5.16	5.18
Middle East North Africa	2.94	3.88	5.20	6.09
South Asia	1.75	2.90	4.59	5.58
Africa[b]	1.78	2.27	2.15	2.17

Notes: na, not available. [a]The period 2011 and 2012 was not included because data were not available for the regions. [b]Africa here comprises mainly Sub Saharan Africa (SSA) countries
Source: Adapted from Osabuohien, Efobi and Gitau (2014, p. 3)

Africa has increased its contribution of CO_2 emission to the world total CO_2 emission, as her contribution increased from 1.78 per cent in 1971-1980 to 2.15 in 1991-2000 and further increased by 0.02 per cent in 2001-2008. Compared to other regions in the world, Africa has not contributed much to the total world emissions. Reducing the impact of these challenges in the region will require policy intervention to control the rate of emission of these gases, which leads this study to observe the trend of institutional quality in Africa. In this case, institutional quality is conceptualized as policies and regulations such as emission taxes, which can control the impact of the activities of the tripod on the environment. For these policies to be effective there is the need for responsive governance, reduction in the rate of corruption and improved regulatory quality. These measures of institutions are reported in Table IV for differentregions of the world.

From Table IV, African countries have remained below the world average and other regions, in institutional quality. Using the control of corruption measure, the incidence of corruption persist more in Africa than other regions of the world, with values ranging from −0.58 to −0.68 for the period 1996-2008. Likewise, the responsiveness of the government to making sound policies and enforcing such policies (measured by government effectiveness) was lowest in Africa with values ranging from −0.66 to −0.78 compared to the world average (−0.01 and −0.04). The quality of the government regulation in Africa also lends support to the fact that African countries have remained behind in institutional quality compared to other regions of the world.

Table IV. Institutional quality**

	Control of corruption				Government effectiveness				Regulatory quality			
	1996	2000	2005	2008	1996	2000	2005	2008	1996	2000	2005	2008
EAP	−0.43	−0.6	−0.53	−0.57	−0.3	−0.48	−0.46	−0.53	−0.35	−0.61	−0.56	−0.69
ECA	−0.7	−0.62	−0.52	−0.48	−0.58	−0.51	−0.37	−0.31	−0.59	−0.49	−0.32	−0.1
LAC	−0.35	−0.18	−0.16	−0.12	−0.34	−0.15	−0.14	−0.1	0.22	0.07	−0.07	−0.12
MENA	−0.46	−0.57	−0.55	−0.62	−0.45	−0.63	−0.63	−0.61	−0.64	−0.78	−0.73	−0.63
SSA	−0.63	−0.58	−0.68	−0.62	−0.66	−0.72	−0.78	−0.78	−0.65	−0.64	−0.75	−0.7
World	−0.03	−0.02	−0.02	−0.02	−0.04	−0.01	−0.01	−0.01	−0.05	−0.03	−0.02	−0.01

Notes: The values ranges from −2.5 (worst) to +2.5 (best), i.e. the higher the better. EAP, East Asia and the Pacific; ECA, Europe and Central Asia; MENA, Middle East and North America; LAC, Latin America and Caribbean; SSA, Sub Saharan Africa. The years reported are those that have values for the regions afterwards the data has been mainly reported for countries not regions. **Significant at 5 per cent level

Source: World Governance Indicators as computed by Kaufmann *et al.* (2010) for the World Bank (2012)

A surmise from this section reveals the rising level of trade, MNCs, energy consumption and emissions in Africa. Furthermore, the low level of institutional quality, questions the capacity of African institutional development to protect the environment. However, empirical evidence will be used to unravel this relationship in subsequent sections.

3. Brief review of literature

Green growth, which considers the sustenance of the environment in the development process, is one of the fastest growing literatures in economic discipline. There is wide cognizance that failure to attend to environmental issues will reverse the steps achieved in the development process in terms of reducing poverty and income inequality. This is because the poor are more vulnerable to environmental challenges due to limited adaptation and mitigation measures. Changing climate patterns affects the productivity of agricultural sector leading to higher cost of living. However, changes in climatic patterns are mostly caused by the increase of GHG (such as (CO_2), into the atmosphere (US Environmental Protection Agency, 2014)). World Bank (2007) argues that though the developed countries has been the main sources of GHGs in the next decade, the significant emissions will occur from the developing countries and hence important to understand the dynamics of climate change in this regions.

The activities of the tripod cannot be exonerated from the increasing deposit of GHG in the atmosphere. For instance, Osabuohien *et al.* (2013) established the activities of MNCs in Africa exert a positive influence on the rising CO_2 emissions that is experienced in the region. The activities of MNCs on global environmental issues has even received global attention, which led to the development of protocols, like the Kyoto protocol[1], to curtail the volume of GHG emissions; although, the extent of compliance by MNCs is not yet fully verified (Pinkse and Kolk, 2007). The protocol also emphasized the support for renewable energy, improving energy efficiency and reducing deforestation. Some of these emphasizes are directly linked to MNCs and trade (Lau *et al.*, 2014).

From a policy perspective, the implications of countries' trade policies have an effect on the environment. For example, the United Nations Development Programme (UNDP) in 2011 observed that developing and least developed countries that have pursued export led growth policies, by relying on primary agricultural or mineral products have resulted in the depletion of the natural resources of the countries (United Nations Development Programme (UNDP), 2011). Worth mentioning is the adverse effect of trade agreements on environmental pollution. The case of some developing countries that have experienced increased environmental pollution after the signing of trade agreement is a good instance (Gallagher, 2004). Some other policy instances that have affected the environment is the increasing trend in the energy prices, motivated Peru to enhance oil and gas exploration activities in the Amazonian forest and the consequences of this action is hostile on biodiversity (Finer *et al.*, 2008).

Climate change and the accompanying environmental challenges is an urgent and serious problem (Stern, 2004) and addressing these challenges requires long-term policies and coordinated actions. In developing countries, environmental challenges are twofold; as a result of underdevelopment which leads to environmental degrading economic activities like deforestation as a result of charcoal burning and firewood collection. In addition, economic activities to achieve development like the setting up of industries and application of fertilizer emits GHGs, (Jha and Whalley, 2001).

Meltzer and Sierra (2011) note that there are several links between trade and climate change. Trade contributes to economic growth but might lead to increased emission of GHG, similarly climate change policy might influence the trading systems that prevails between countries, which might affect the competitiveness of a country in the international market. Alam *et al.* (2011) find that in Pakistan trade liberalization affects the environmental degradation and economic growth. The results concur with Abdulai and Ramcke (2009) who used panel data to assess the link. This is because polluting industries will migrate from developed countries to developing countries that have pollution havens but poorly regulated.

Young (2003) argues that there are institutional eccentrics that are often difficult to eliminate and they influence the effectiveness of national and international environmental policies. On the other hand, international policies have not achieved because of lack of sanction institutions and mechanisms. At national institutional agents-the governments and corporations are responsible environmental problems other than individuals in the forward-looking responsibility approach (Fahlquist, 2009). According to Meadowcroft (2009) the state requires institutions capable of altering the way things are done so as to bring about changes on people's perceptions to become active participants in addressing climate change menace. In this light, Osabuohien *et al.* (2014) in a recent paper, based on a sample of African countries, have advanced the need for the productive process of firms and behavioural patterns of citizens to be curtailed in the interest of the environment, which can be made possible by the regulative and normative institutional structure in the African continent.

It is important to give clarification to the concept of institutions in order to underpin the foregoing arguments on the relevance of institutional settings in enhancing environmental sustainability. Among the earlier institutional theorist was Commons (1931), who defined institutions as the collective action in the control and liberation of individual action. By this definition, institutions are expected to perform a dual role of constraining and allowing economic activities. However, institutions do not just exist. Instead it is humanly devised constrains, aimed at structuring human interactions (North, 1991). They can be in the form or formal or informal institutions, depending on the framework that establishes these constraints. For instance, the formal institutions are established on the framework of the state and it is being governed by constitutional dictates or acts enacted through a formal legislative process. On the other hand, the informal institutions include norms, beliefs and traditions that can define the behaviour of individuals[2].

Focusing on formal institutions, its functionality in the state include: allow the decreasing of uncertainty that is faced by agents in an economic relationship; it defines the incentive structure of societies and the economic system (North, 1991); it explicitly or implicitly creates the contractual framework that governs the transaction between economic agents (Williamson, 2000). Relating this functionality to the environment, MNCs activities, trade and energy; the role of institutions can be seen in the reduction of possible environmental uncertainties that stems from the activities of the tripod. Institutions are supposed to create the framework that reduces the adverse consequences from the presence of the tripod in an economic system. Osabuohien *et al.* (2013) emphasized this focusing mainly on MNCs activities in selected African countries; while this present study further elaborates on the role of institutions in mitigating the adverse effect of the tripod on the environment.

4. Method of analysis and data

We extend the baseline Environmental Kuznets Curve (EKC[3]) model by the inclusion of the tripod: the equation is presented as:

$$Enc_{it} = \alpha_i + \gamma_t + \beta_1 GDPP_{it} + \beta_2 (GDPP)^2{}_{it} + \beta_3 Trad_{it} + \beta_4 MNC_{it} + \beta_5 Eletenegy_{it} + \varepsilon_{it} \quad (4.1)$$

The role of institutions as a control mechanism is also introduced by the interactive variable "interact". The main purpose for the inclusion of the interaction variables is to investigate whether the tripod play substitutive or complementary role in exerting influence on the dependent variable. Thus, will institutional quality act as "buffer" in terms of the influence of the tripod on environmental challenge or not? Therefore, equation (4.1) is re-written as:

$$Enc_{it} = \alpha_i + \gamma_t + \beta_1 GDPP_{it} + \beta_2 (GDPP)^2_{it} + \beta_3 Trad_{it} + \beta_4 MNC_{it}$$
$$+ \beta_5 Eletenegy_{it} + \beta_6 Institution_{it} + \beta_7 nteract^k_{it} + \varepsilon_{it} \quad (4.2)$$

where *Enc* is the environmental challenge is measured using CO_2 emission per capita. CO_2 emission per capita was used as a proxy because it constitutes the largest component of total GHG emissions in the world (World Bank, 2007)[4]. *GDPP*, the economic growth measured as GDP per capita, i.e. GDP divided by the total population. $(GDPP)^2$, the squared value of *GDPP*. From the basic EKC tenet, the inclusion of this variable is essential to investigate the existence of an inverted U-shaped parabolic relationship between environmental pollution and economic growth in a country; that is whether environmental pollution can reduce with high level of income or not (Stern, 2004; Taguchi, 2012; Osabuohien, *et al.,* 2014). *Trad*, the trade, measured as the sum of exports and imports of goods and services as a share of GDP. This shows the relative openness of the country to trade. *MNC* the multinational inflow, measured as foreign direct investment (FDI) net inflow as share of GDP. *Eletenegy*, the electric energy consumption, measured as electric power (kwh) per capita. This measure is preferred because it captures the amount of electric energy usage per the population of the country and gives a broad view of energy distribution in the country. Other alternative sources of energy like nuclear, solar are not popular in Africa; and the data on them are also scanty for many African countries. *Institution*, the institution is measured as an average of three measures (control of corruption, extent of government effectiveness and the rule of law in the country), as computed by Kaufmann *et al.* (2010). The average was used because it is able to capture a more robust perspective of institutions. Control of corruption shows the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. Government effectiveness reflects the quality of public services, the quality of the civil service, the quality of policy formulation and the commitment of the government to such policy. The rule of law shows the extent to which economic agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. The values of these measures range from −2.5 to +2.5, signifying the higher the better. $interact^k$, the interactive variable between the *tripod* and institutions ($K = 1\text{-}3$). Thus, K includes the multiplicative between institution and trade (*inst_Trad*), institution and MNCs inflow (*inst_MNCs*) and institution and energy (*inst_Eletenegy*). *e*, the error term. *it*, the country ($i = 1,2,\ldots,27$) and time identifiers ($t = 1996\text{-}2010$). α_i and γ_t the stochastic shocks that are common across the countries and the time varying omitted variables. $\beta_{1\text{-}6}$ the coefficients of the explanatory variables to be estimated.

The a priori expectation is such that β_2 and $\beta_6 < 0$ and $\beta_{1,3,4}$ and $\beta_5 > 0$. This implies that an increase in the value of per capita GDP, trade, MNCS inflow and energy consumption will bring about an increase in environmental challenge, while the non-linear form of per capita GDP (GDPP^2) and the interactive measures will reduce environmental challenges.

The dynamic panel data estimation technique is used in the estimation process. This technique underscores the dynamism that exist in the model, such that the dependent variable is not only determined by the explanatory variables but by its lagged values. Specifically, the system generalized method of moment-SGMM as suggested by Bond *et al.* (2001) and Arellano and Bover (1995) are used in the estimation. This is because of the problem of endogeneity that pervades most econometric modelling.

Thus, the dynamic model:

$$Enc_{it} = \alpha_i + \gamma_t + \beta_1 GDPP_{it} + \beta_2 (GDPP)^2{}_{it} + \beta_3 Trad_{it} + \beta_4 MNC_{it} + \beta_5 Eletenegy_{\mathrm{it}} + \beta_6 Institutions_{it} \beta_7 Interact^k{}_{it} + \Sigma_{j=1}^{N} \delta_1 \gamma_t + \pi_i + e_{it} \quad (4.3)$$

where ($E_{i,t-1}$) is the lagged dependent, summation of the exogenous period-specific (γ_t) and country-specific effects (π_i) variables.

The Sargan test of over-identification and the second order serial correlations ($AR(2)$) are used to ensure that the instruments included in the dynamic model are not over-identified and there are no second order serial correlations in the equation. The probability of the Sargan and the $AR(2)$ are expected to be greater than 0.05 to confirm the validity of the instruments and the rejection of first order serial correlation ($AR(1)$) in levels. The model is estimated using STATA 11.1 and GRETL econometric softwares.

In total, 27 African countries were selected for the period 1996-2010[5], based on data availability. The selected countries include Algeria, Angola, Benin, Botswana, Cameroon, Congo Democratic, Congo Republic, Cote d'Ivoire, Egypt, Eritrea, Ethiopia, Gabon, Ghana, and Kenya. Others include: Libya, Morocco, Mozambique, Namibia, Nigeria, Senegal, South Africa, Sudan, Tanzania, Togo, Tunisia, Zambia, and Zimbabwe. These countries constitute more than 80 per cent of Africa's economic activities (GDP) and population.

Summary statistics of the variables in the model are presented in Table V. From the table, the entire sample had an average of 33,658.3 kt of carbon emissions for the entire period. Some countries such as Algeria, Egypt, Nigeria and South Africa had an emission kt that was over two times the volume of the entire sample. South Africa was the highest emitter while Eritrea had the lowest volume of emission.

With regards to the economic performance of the sampled countries (GDPP), the entire sample had an average per capita GDP of 1,683.3 US dollar. Libya's per capita GDP, which was the highest, was 4 times the entire sample average. The top five economic performers (in US dollars), ranked in ascending order, were Namibia (3,018.9), South Africa (4,351.02), Botswana (4,681.7), Gabon (5,762.1) and Libya (7,373.4). During the period, the average trade value for the entire sample was 71.9 per cent. This implies that on the average, total trade is able to account for 71.9 per cent of the GDP of the sampled countries. Some countries such as Angola and Congo Republic had their total trade accounting for over 100 per cent of their GDP. Some others like Sudan and Ethiopia had their total trade contributing minimally to their GDP.

The average MNCs inflow for the entire sample was only 3.3 per cent of the GDP. This implies that on the basis of MNCs contribution to GDP, the inflow of MNCs in the sampled countries is able to contribute a meagre 3.3 per cent to their economies. Most of the countries had less than 10 per cent contribution of MNCs inflow except for Congo Republic (12.3 per cent). Some other countries such as Gabon and Kenya had contributions less than 1 per cent. Gliding to the indicator of energy, the table revealed

	Enc	*GDPP*	*Trad*	*MNC*	*Eletenegy*	*Inst*
All sample	*33,658.30*	*1,683.28*	*71.87*	*3.33*	*668.47*	*−0.61*
Algeria	97,503.28	27,18.33	59.85	1.20	772.49	−0.66
Angola	14,236.99	1,832.52	131.59	9.41	119.19	−1.20
Benin	2,279.18	520.72	42.42	1.81	68.31	−0.43
Botswana	4,148.51	4,681.67	84.82	4.47	1,240.29	0.55
Cameroon	3,966.28	863.84	45.57	1.34	197.58	−0.82
Congo Rep	1,374.00	1,529.01	135.08	12.26	119.16	−1.26
Congo, Dem. Rep.	2,299.21	132.41	56.57	6.02	92.23	−1.72
Cote d'Ivoire	7,155.73	881.05	80.83	2.15	180.32	−0.99
Egypt	149,460.72	1,521.26	50.67	3.03	1,153.48	−0.35
Eritrea	596.03	243.11	73.26	3.78	51.58	−1.13
Ethiopia	5,232.53	191.08	39.57	2.44	31.16	−0.73
Gabon	1,968.90	5,762.07	94.84	0.10	926.53	−0.68
Ghana	7,324.97	624.72	85.42	2.95	294.02	−0.10
Kenya	9,099.80	541.68	58.24	0.55	132.83	−0.58
Libya	50,165.12	7,373.40	72.66	1.43	2,817.86	−1.05
Morocco	38,252.17	1,838.95	66.13	1.59	579.52	−0.12
Mozambique	1,656.64	293.30	64.18	5.29	282.99	−0.45
Namibia	2,382.42	3,018.85	95.30	2.53	1,266.49	0.14
Nigeria	766,96.72	682.48	74.06	3.44	101.21	−0.98
Senegal	4,479.95	735.64	66.73	1.76	144.05	−0.23
South Africa	386,952.55	4,351.02	55.98	1.60	4,590.53	0.55
Sudan	8,412.10	696.83	34.15	4.59	70.46	−1.23
Tanzania	3,995.06	356.42	48.21	3.14	66.15	−0.46
Togo	1,281.19	386.33	84.08	2.42	108.09	−1.36
Tunisia	20,803.46	3,008.27	89.94	3.24	1,078.22	0.46
Zambia	2,033.77	617.08	70.33	5.93	659.60	−0.83
Zimbabwe	12,172.18	515.01	82.76	1.30	904.27	−1.02

Source: Authors' computation

Table V.
Mean statistics of variables across sampled countries

that on the average, the electric energy consumption for the entire sample was 668.5 kwh, South Africa (4,590.5 kwh) consumed as much as 6 times the entire sample and about 147 times than Ethiopia (31.2 kwh).

Comparing the institutional variables across the sampled countries, the values from the table reveal that on the average, the selected countries had weak government effectiveness. The value, −0.61, was below the average, considering that the measures range from −2.5 (weak institutions) to +2.5 (strong institutions). As earlier observed by some studies (e.g. Fosu, 2008), most countries in Africa with better institutions were located in the southern region. The table confirms this as South Africa (0.55), Botswana (0.55) and Namibia (0.14) takes the lead for better institutional quality. Countries like Congo Democratic, Togo, Congo Republic and Sudan were at the bottom echelon.

5. Empirical results and discussions

The econometric results[6] obtained from the estimation – using the SGMM estimation technique – were reported in Tables VI-VIII. The Sargan test of over-identifying restrictions confirms the joint validity of the internal instruments that were included in model. The *p*-value of the Arellano-Bond test for second-order serial correlation in differences (*AR* (2)) and the first-order serial correlation (*AR* (1)) in levels confirms that there was no serial correlation in the residuals. The implication of this is that the results

Table VI. SGMM result when considering trade

	1	2	3	4	5	6
Enc	0.352* (0.000)	0.980* (0.000)	0.981* (0.000)	0.239* (0.000)	0.980* (0.000)	0.977* (0.000)
PGDP	0.246* (0.000)		0.052* (0.000)	0.220* (0.000)	0.040* (0.000)	
$PGDP^2$		0.027* (0.000)				
Trade	−0.001* (0.002)	−0.001* (0.000)	−0.001* (0.000)	0.002** (0.030)		
Inst.	0.030* (0.000)	0.010*** (0.094)	0.036* (0.009)	0.108** (0.019)		
Inst_Trade			0.001* (0.000)		0.001* (0.000)	
Inst_Trade (−1)				−0.002* (0.000)		−0.001** (0.041)
Constant		0.244* (0.000)	−0.266* (0.000)	−0.014 (0.099)	−0.211* (0.000)	−0.346* (0.000)
AR(1)	0.024	0.026	0.026	0.019	0.026	0.016
AR(2)	0.614	0.400	0.396	0.497	0.404	0.132
Sargan	0.900	0.999	0.990	0.999	0.998	0.999
Wald	0.000	0.000	0.000	0.000	0.000	0.000

Notes: The probability values are in parenthesis. The variables except the interactions are in their logarithmic form. *,**,***Significant at 1, 5, and 10 per cent, respectively
Source: Authors' computation

Table VII.
SGMM result when considering MNCs

	1	2	3	4	5	6
Enc	0.982* (0.000)	0.936* (0.000)	0.979* (0.000)	0.935* (0.000)	0.984* (0.000)	0.980* (0.000)
PGDP	0.040* (0.000)		0.043* (0.000)	0.034* (0.000)	0.039* (0.000)	0.058* (0.000)
$PGDP^2$		0.036* (0.002)				
MNC	0.004* (0.000)	0.004* (0.000)	0.009* (0.006)	0.013** (0.000)		
Institutions	0.017* (0.001)	0.024* (0.000)	0.035* (0.000)	0.054 (0.355)		
Inst_MNC			-0.006* (0.000)		0.001* (0.003)	
Inst_MNC (−1)				−0.013* (0.000)		−0.005* (0.000)
Constant	−0.208* (0.000)	−0.492* (0.004)	−0.204* (0.010)	−0.169 (0.539)	−0.223* (0.000)	−0.362* (0.000)
AR (1)	0.025	0.044	0.045	0.017	0.026	0.014
AR (2)	0.421	0.537	0.540	0.685	0.408	0.148
Sargan	0.900	0.999	0.990	0.999	0.998	0.999
Wald	0.000	0.000	0.000	0.000	0.000	0.000

Notes: The probability values are in parenthesis. The variables except the interactions are in their logarithmic form. *,**,***Significant at 1, 5, and 10 per cent, respectively
Source: Authors' computation

Table VIII. SGMM result when considering electric energy

	1	2	3	4	5	6
Enc	0.983* (0.000)	0.983* (0.000)	0.979* (0.000)	0.935* (0.000)	0.984* (0.000)	0.979* (0.000)
PGDP	0.042* (0.000)		0.044* (0.000)	0.015* (0.000)	0.042* (0.000)	0.060* (0.000)
PGDP^2		0.021* (0.000)				
Eletenergy	−0.003 (0.428)	−0.003 (0.428)	0.008 (0.260)	0.001 (0.927)		
Institutions	0.019** (0.014)	0.019* (0.000)	−0.076** (0.028)	0.060* (0.000)		
Inst_*Eletenegy*			0.016* (0.001)		0.003* (0.000)	
Inst_*Eletenegy* (−1)				−0.008* (0.000)		−0.001*** (0.079)
Constant	−0.216* (0.000)	−0.216* (0.000)	−0.299* (0.000)	−0.072* (0.000)	−0.236* (0.000)	−0.362* (0.000)
AR(1)	0.025	0.025	0.025	0.041	0.025	0.017
AR(2)	0.412	0.412	0.417	0.523	0.413	0.133
Sargan	0.900	0.999	0.990	0.999	0.998	0.999
Wald	0.000	0.000	0.000	0.000	0.000	0.000

Notes: The probability values are in parenthesis. The variables except the interactions are in their logarithmic form. *,**,***Significant at 1, 5, and 10 per cent, respectively
Source: Authors' computation

are useful for inferences as the instruments are not proliferated. This is further buttressed by the probability values of the Wald test, which confirms that the explanatory variables are jointly significant in explaining variations in the dependent variable.

It can be observed from Tables VI-VIII that the lagged values of environmental pollution significantly explain its future occurrences, implying that time matters in explaining the rising rate of environmental challenge in Africa. In this context, the lagged values of CO_2 emission in the first rows had a positive and significant sign, denoting that the past volume of emission has a direct and significant effect on the current volume. This explains why areas that are prone to a particular environmental challenge at a given point in time will likely experience same in the future except for timely interventions. The continuous occurrences of flooding in many parts of Africa are instances to this finding.

The other covariates (e.g. per capita GDP) were significant and had a positive influence on environmental challenges. The squared value of per capita GDP was also positive and significant but experienced a decreasing effect (see Columns 1 and 2 in Tables VI-VIII). This suggests the existence of an inverted positive association between economic growth and environmental challenge in the sampled countries. This follows the argument of Grossman and Krueger (1993) that environmental pollution can reduce with higher levels of income. Panayotou *et al.* (2000) reached similar conclusion by noting that higher levels of economic growth will bring about structural changes that will shift the production and industrial activity from high to low environmental pollution.

In Table VI, the trade variable presented a mixed behaviour. It was negative and significant in all the columns except for the fourth. A closer investigation of this variable shows that the level of influence range from 0.001 to 0.002. This reveals that the influence of trade on the environment of African countries is minute. However, regarding the direction of the impact, trade does not display a considerable contentious threat to African countries, since the impact is less than 0.01 per cent.

Considering the impact of MNCs, Table VII presents a consistent and significant positive influence of MNCs inflow on environmental challenge in Africa with magnitude of influence ranging from 0.004 to 0.013 as can be seen in Columns 1-4. The activities of MNCs, especially resource seeking and those involved in manufacturing, affects the environment of African countries. Perhaps, their extractive and productive machineries are not environmentally friendly and the CO_2 that are being released cannot be exonerated from the bulk Africa's contribution of global GHG. For policy action, there is a need for control of the extent of environmental pollution from the activities of MNCs. This policy recommendation further lend voice to Osabuohien *et al.* (2013), who also found a significant linkage between the activities of MNCs in African countries and the extent of environmental pollution.

The last tripod – electric energy (measured as electric energy consumption per capita) displayed a consistent insignificant influence on environmental pollution. This result is not too surprising owing to the fact that African countries have, over the years, witnessed an inefficient supply of electric energy. In many African countries, most industrial hubs depend on self-generated energy supply in the form of generator sets, which is likely to explain the reason why this variable did not exert a significant influence on the environment pollution. In essence, the rising environmental pollution in most African countries cannot be considerably linked to the public electricity supply but to other source of energy[7].

Taking the discussion further, the role of institutional quality is examined by the interactions variable between institutions, trade, MNCs and electric energy (*inst_trad, inst_mnc* and *inst_eletenegy*). The variables exhibit a negative and significant influence on environmental challenge at its lagged values, denoting that the quality of institutions can help to curtail the adverse effects of the tripod when time is considered (see the seventh row of Tables VI-VIII). The implication of this finding is that the current improvement of institutional quality will help to suppress the future negative excesses (like pollution) from the activities of trade, MNCs and electric energy consumption, and consequently reduce environmental challenges. This finding is of policy essence as African countries should timely relate their need for improved trade competitiveness, attracting foreign capital inflow and energy production to boost industrialization, with the development of their institutional framework.

The findings from this study underscore the urgent need for African countries to improve their institutional quality for efficiency in protecting the environment. Institutional enhancement should move beyond action plans and protocols to greater enforcements. Some of the prominent regional environmental protocols include the West and Central Africa Regional Framework on Air Pollution in 2009, Eastern Africa Framework Agreement on Air Pollution in 2008 and the Southern African Development Community (SADC), tagged Lusaka agreement (2008). These protocols have focused on air pollution, which is directly linked to climate and environmental changes. However, the need for a comprehensive and quick environmental policy implementation, regional coordination of the protocols and better legal enforcement, is encouraged for better outcomes.

6. Conclusion

The main motivation of this study is the somewhat growing consensus that trade, multi-national corporations (MNCs) inflow and energy (simply denoted as the tripod) contribute to the economic growth process of countries and the little attention on the possible resultant implications that they permeate on the environment, especially in Africa. This is particularly important as many African countries may not have the needed technology, institutional quality for adaptation to the changing environment.

Based on the empirical analysis, it was also established that current level of environmental challenge will have predictive implication on its future values, which suggests that curtailing environmental challenges for the future needs a proactive action in the current year. To further substantiate, the role of institutional framework in helping to dampen the impact of environmental challenges in relation to the tripod should not be undermined. The result from the interactive variables between institutions and the tripod reflect that institutional framework is quite imperative. This implies that institutional quality, relating to the effectiveness of the government of a country especially in formulating and enforcing adequate environmental policies, is an essential determining factor in ameliorating the extent of environmental challenge.

The key policy message from the findings in this study is that regulations that have to do with the environment are essential in curtailing the excesses of economic activities and eventually help in reducing the trilemma (possible adverse effects) that are emanating from the tripod. Furthermore, institutional improvement such as the establishment of regional coordination organ to foster plans and protocols should be given political will that are useful for a timely enforcement of such policy stipulations. Some of these plans and protocols include the West and Central Africa Regional Framework on Air Pollution (adopted in 2009); Eastern Africa Framework Agreement on Air Pollution (adopted in 2008); and the Lusaka Agreement (of 2008) for the SADC and by improving institutions, these protocols are given legal enforcement, which is *sine qua non* for their implementation.

Notes

1. Kyoto Protocol is an international agreement that is linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets. The Protocol was adopted in Kyoto, Japan, on 11th December 1997 and entered into force on 16th February 2005.
2. In this study, focus is on the formal institutions. As one of the reviewers suggested, they may be need for further studies to investigate how the informal institutions influence the way countries handle environmental issues. This can be done through case studies by interviewing political actors on their motivations, rationales and readiness in changing regulatory framework that are related to the environment.
3. The basic Environmental Kuznets Curve (EKC) maxim shows the possibility of an inverted *U-shaped* parabolic relationship existing between environmental pollution and economic growth. Stern (2004), Taguchi (2012) and Osabuohien *et al.* (2014) provide recent discussions on EKC based on different countries and regions.
4. We used other indicators for ENC (notably particulate matter); however, there was no discernible difference in the pattern of results (not reported).
5. An attempt was made to increase the period to 2012; however, most of the variables did not have values up to 2012.
6. A correlation test was conducted. The results (not reported) indicate that there was no issue of multicollinearity except between the per capita GDP and its squared value, which informed their stepwise use.
7. In this case, a positive relationship between the importations of electricity generated set and environmental pollution can be expected, which is outside the scope of this study.

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