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Foreign Direct Investment and Pollution Haven: Does Energy Consumption Matter in African Countries?

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ABSTRACT

This study empirically examines the relationship between foreign direct investment, energy consumption, and environmental pollution on 19 African countries over the period 1990–2010. Relying upon the Pooled Mean Group (PMG) estimation technique, our empirical findings, in consonance with the literature, demonstrate that energy consumption does have a positive elasticity effect on carbon dioxide emissions. Likewise, our results find that energy intensity associated with FDI inflows has a significant increasing effect on the greenhouse gas emissions across the sample countries. The study also provides evidence validating the presence of pollution haven hypothesis for carbon dioxide emissions. Moreover, there is also an indication that current foreign investment and energy policies in Africa may not be favourable to the environmental quality in the continent. This, therefore, indicates that incorporating issues of environmental conservation in both foreign investment and energy policies can reduce pollution emissions in the continent. Hence, in order to reduce emissions, the best environmental policy is to encourage inflows of multinational firms that abide by global technology standard, which in a way can facilitate domestic energy efficiency, thereby reducing pollution emissions.

Keywords: Foreign direct investment, energy consumption, pollution haven hypothesis, energy intensity, Africa, PMG

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INTRODUCTION

In recent years, partly as a consequence of substantial increase in foreign direct investment (FDI) inflows, many countries in Africa have experienced improvement in their economic growth (see Al-mulali and Che Sab, 2012; Adams, 2009). One source of concern is that the increasing openness of the continent to the global economy, which facilitated its access to more foreign investment, may likely constitute higher energy consumption and substantial consequences of pollution emissions. There has been an argument that foreign investment policies in most of countries in Africa, being dominantly resource – dependent substantially favours extractive sectors (see African Union, 2009) and, these sectors are often associated with negative environmental consequences (Azapagic, 2004). Although, at the global scale, Africa may be the least emitter of greenhouse gases (GHGs)[1], the connection between economic progress and energy intensity in the continent (Al-mulali and Che Sab, 2012) like many of the least developed countries or regions could be profoundly influenced by improvement of living conditions with less or no emphasis on the quality of environment for some time[2]. Within this content, people in the continent would be less sensitive to pollution, and as such may be reluctant to facilitate either formulation or reinforcement of environmental regulations. This issue holds great significance, particularly considering African countries that are quite weak in terms of environmental regulations compared to advanced nations. This has a tendency of turning the continent into havens for polluting multinationals from advanced nations that have strict environmental laws, thereby justifying what is often referred to as a pollution haven hypothesis. This postulated energy demand-pollution emissions relation, however, received little attention within the context of Africa.

Despite the established link between FDI and energy use (e.g. Omri and Kahouli, 2014), as well as energy consumption and pollution emissions (e.g. Chang, 2010; Alam, Begum, Buysse, Rahman and Van Huylenbroeck (2011); Al-mulali and Che Sab, 2012) available evidences make little effort to account for energy consumption on the foreign investment - pollution relationship. More in general, most of the available evidences as observed by Hübler and Keller (2010) focused on microeconometric investigations using firm-level dataset. However, best known to us there is restricted or no comprehensive macro panel data investigation that analyses FDI, energy consumption and pollution emissions from the perspective of pollution haven hypothesis, especially in African countries. This is unfortunate, considering its relevance from environmental policy outlook on the continent.

[1] See, for example, Patz, Gibbs, Foley, Rogers and Smith (2007); IPCC (2007)
[2] See Wolfram, Shelef and Gertler (2012)

This research therefore contributes to the existing literature by incorporating energy consumption into FDI-pollution nexus. The study also examines the impact of environmental regulation on the pattern of African inward FDI flows and the possible existence of the pollution haven hypothesis across the continent. To achieve these objectives, the paper adapted the framework developed by Antweiler, Copeland and Taylor (2001) and Cole and Elliott (2003) which is suitable for decoupling environmental effect of FDI and also examine changes in pollution that might emanate from differences in environmental laws arising from unequal distribution of income between Africa and their investment partners possibly from relatively advanced nations. Previous attempts to investigate these relationships in the continent are relatively scarce. Available evidences mostly focus on the effects of energy consumption and economic growth on pollution emissions (see, for example Al-mulali and Che Sab, 2012) and, place meagre effort to investigate pollution effect of energy consumption and its intensity, particularly with regard to FDI inflows. Confirming the pollution haven hypothesis is indispensable from the policy perspective. If the hypothesis is supported, it may serve as a guide for a future policy formulation that can appropriately lessen the environmental problem associated with foreign investment in the continent.

REVIEW OF RELATED LITERATURE

Economic explanation concerning the relationship between FDI, environmental regulation and pollution emissions suggests more than one hypothesis. Pollution haven hypothesis suggest that free movement of capital across nations in the form of FDI is partially driven by variation in environmental regulation, and that higher income countries incur higher cost of pollution control when compared with their counterparts in low income countries (LICs). This scenario tends to create a source of comparative advantage for LICs to attract pollution generating multinational firms. This accordingly would lead to laxity of environmental regulation in low income countries, and thus subjecting them to specialize in polluting sectors, whilst advanced countries specialize in clean production. Within this context, LICs would turn into a haven for polluting firms relocating from higher income nations (Wheeler, 2001). Contrary to this hypothesis is the neo-technological theory which attributes positive environmental effect to FDI inflows. Example of this theory is the pollution haloes hypothesis which argued that FDI increases the chances for ecological sustainability via transfer of environmentally friendly technology from advanced nations to less developed ones (Hassaballa, 2014).

The nexus between direct foreign capital inflows and environmental pollution can also be theoretically viewed in the form of structural linkage: the composition, scale, and technique effects (see, for example, Frankel, 2009). The composition effect refers to the manner that direct capital flow from foreign countries modifies the combination of a country's production towards those goods where it has a comparative advantage. The greenhouse gas effect of these resources re-allocation process within a domestic economy will, for example, depend on the sectors in which a country has comparative advantage. The composition effect will result in more greenhouse gas emissions, if the expanding sectors are more energy-intensive relative to the contracting sectors, and vice-versa. In the case of Africa, if, for example, FDI induces the continent's extractive and heavy industries to expand and its service sector to contract, the aggregate emissions across the continent will likely increase since the growing sector is more energy intensive. The Scale effect denotes to the effect on greenhouse gas emissions from the increased economic activity and/or output resulting from more foreign investment.

The overall presumption is that FDI will increase economic activity and hence energy use. All things being equal, this increase in the scale of energy use and economic activity will lead to higher levels of greenhouse gas emissions. This implies that higher incomes increased pollution due to greater energy consumption. Thus, economic integration, which accelerates economic growth through scale effect has a negative consequence on the environment (see Copeland and Taylor, 1994, 2003). The technique effect designates FDI inflows that led to improvements in energy efficiency, so that the production of goods and services generates less pollution to the environment, which implies decline in emission intensity. FDI-lead technique effect could be realized by its direct contribution in pollution reduction capacity, for example, based on the analogy of porter hypothesis (Porter and van der Linde, 1995). This hypothesis suggests that the stringency of environmental regulation, say, in advanced nations would likely encourage innovation and replacement of pollution generating production process with more efficient and more environmentally-friendly technology, which would be ultimately transferred to less developed countries via FDI flows, and thus less environmental damage. Similarly, additional access to foreign capital increases income which can make society to demand for a better environment, hence, low pollution emissions (Grossman and Krueger, 1994; Grossman, 1995 in He, 2006).

Available empirical literatures on the environmental regulatory effect of FDI are at best not unanimous in their submissions. For example, empirical works by List and Co (2000) and Hassaballa (2014) among others, show that stringent environmental regulations which have significant influence on pollution abatement costs, do affect the location of multinational firms across – countries or – regions. In a similar study by Cole and Elliot (2005) on the US outward FDI, their result indicated that difference in pollution abatement costs has positive relationships with the FDI outflows across manufacturing firms. However, as established in some empirical works (Eskeland and Harrison, 2003; Kirkpatrick and Shimamoto, 2008; Hanna, 2010) multinational firms in countries with relatively lax environmental regulations are significantly more environmentally – friendly and use more efficient energy than their local counterparts. The inconsistent inferences from these studies made it difficult to draw general conclusions with regard to the interrelationship between FDI location and environmental regulations.

Although, the empirical relationship between energy consumption and pollution emissions have been intensively examined in the past two decades. However, such empirical evidences appear to be inconclusive. For example, while studies by Soytas, Sari and Ewing (2007), Zhang and Cheng (2009), Chang (2010) Alam *et al*. (2011), Al-mulali and Che Sab (2012) suggest that energy consumption causes pollution emissions. Ang (2008), on the contrary, failed to establish robust evidence of the explanatory impact of energy consumption on pollution changes. Moreover, Halicioglu (2009) claim that while both income and energy consumption explain pollution emission in Turkey, economic growth appears to be more robust in explaining the pollution scenario in the country. Empirical evidences by Apergis and Payne (2009), Pao and Tsai (2011) and Wang *et al*. (2011) among others, show that both energy usage and pollution emissions are important in determining each other, suggesting joint determination of pollution emissions and energy consumption, the situation that could only be altered by improving energy efficiency. Lack of consensus from these previous works could therefore indicate the need for further research.

MODELS

Following the empirical literatures, this study adapted empirical framework suggested by Antweiler *et al*. (2001) and Cole and Elliott (2003) to evaluate the relationship between foreign direct investment, energy consumption, and environmental pollution, with a view to testing the validity of the pollution haven hypothesis in Africa as follows:

$$\begin{aligned} LE_{i,t} = {} & \alpha_{0i} + \alpha_{1i} LY_{i,t} + \alpha_{2i} LY^2_{i,t} + \alpha_{3i} LFDI_{i,t} + \alpha_{4i} LINV_{i,t} \\ & + \alpha_{5i} LEC_{i,t} + \alpha_{6i} LRY_{i,t} * LFDI_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{1}$$

$i = 1, 2, \ldots, N; t = 1, 2, \ldots, T.$

We also attempt to evaluate whther the effects of both domestic and foreign capital inflows (FDI) are conditional on the domestic energy intensity across the sample countries as follows:

$$LE_{i,t} = \alpha_{0i} + \alpha_{1i}LY_{i,t} + \alpha_{2i}LY_{i,t}^{2} + \alpha_{3i}LFDI_{i,t} + \alpha_{4i}LINV_{i,t} + \alpha_{5i}LEC_{i,t} + \alpha_{6i}LRY_{i,t} * LFDI_{i,t} + \alpha_{7i}LINV_{i,t} * LEI_{i,t} + \alpha_{8i}LFDI_{i,t} * LEI_{i,t} + \varepsilon_{i,t} \quad (2)$$

$i = 1, 2, \ldots, N; t = 1, 2, \ldots, T.$

where E is the per capita environmental stressor (proxies as carbon dioxide emissions, CO_2), α_{oi} denotes country – specific intercept, Y and Y^2 are GDP per capita and GDP per capita squared respectively, RY denotes Africa's relative real income per capita. FDI is defined as foreign direct investment and EC indicates energy consumption (proxies by kilogram of energy use per capita of oil equivalent), INV indicates domestic investment (proxies by gross fixed capital formation) and EI represents energy intensity (proxies by energy use per GDP). t denotes a time trend, while subscripts (i) and (t) indicate individual African country and time, respectively, ε is the usual error term, L indicates a logarithm transformation of the variables.

From eqn. (1), since FDI is known to be an important determinant of national output and, also since the quality of the environment is assumed to be a normal commodity; higher per-capita income would inspire higher public demand for cleaner environment. Such rising demand for environmental quality could then lead authorities to enforce strict environmental laws that might inspire a reaction from domestic firms via the introduction of 'green' or environmentally – friendly technologies. This effect, which is related to Environmental Kuznets (EKC) hypothesis as identified by (Hübler and Keller, 2010) referred to as "income – induced technique effect", which as in Cole and Elliott (2003) is captured by square per capita income, while the scale effect is represented by per capita income (at a lower level of income growth). The composition effect of FDI has significant influence on pollution emission in Africa if either if α_{3i} and α_{7i} or both are statistically significant. The inclusion of energy intensity interactively with FDI is to enable us to examine whether energy intensity can be a potential determinant of FDI–induced pollution emissions in Africa.

Following Antweiler *et al.* (2001) and Cole and Elliott (2003), we construct a relative per capita income as a measure of relative environmental stringency. To test the pollution haven effect associated with FDI inflows, since foreign capital inflows are assumed to stimulate national output, and since more output growth is related to greater energy consumption (See Hübler and Keller, 2010), country's relative income and FDI are interacted to capture environmental regulation effects (that is, the pollution haven effect associated with FDI inflows). Since African countries can generally be considered to have low per capita income, FDI inflows in the continent are expected to increase energy use and pollution emissions. However, fewer emissions may be expected if the foreign multinationals use more efficient and environmentally friendly technologies than their local counterparts in African countries.

METHODOLOGY

Panel Unit Root Tests

Although the PMG or Panel ARDL is appropriate for either of I(0) and I(1) or the mixed of both (Pesaran and Smith, 1995; Pesaran *et al*., 1999), PMG would, however, produce spurious estimate if the order of integration of any of the variables of interest happens to be I(2) (Asteriou and Monastiriotis, 2004). Therefore, before the estimation process it is important to determine the integration order of the study variables. For this purpose, this study considered testing for Unit Roots in the panel dataset using Im, Pesaran and Shin (IPS) (2003) panel unit root test technique. However, for comparison, other unit root tests suggested by Breitung (2001), and Levin, Lin, and Chu (LLC, 2002) were also applied.

Dynamic Panel specifications, the MG and PMG

To examine the long-run effect of FDI and energy consumption on environmental quality, eqn. (1) can be re-written as

$$LE_{i,t} = \alpha_{0i} + \beta_{1i} LFDI_{i,t} + \beta_{2i} LEC + \beta'_{3i}\ LX_{i,t} + \varepsilon_{i,t} \qquad (3)$$

where as specified above, *E* represents the scalar environmental stressor (dependent variable), FDI and EC represent foreign direct investment and energy consumption respectively. X denotes the k x 1 vector of other conditional explanatory variables that affect environmental quality in Africa, β'_i is the k × 1 vector of the coefficients on the regressors, α_{0i}, as specified in eqn. (1 & 2) represents country – specific intercept. The group of conditional regressors comprised of the other explanatory variables specified in eqn. (1 & 2).

Our empirical analysis of model (3) comprises a system of N*T (balanced panel) equations that can be examined either with the Mean Group (MG) estimator, proposed by Pesaran and Smith (1995) and Pooled Mean Group (PMG) suggested by Pesaran *et al*. (1999) all of which account for long-run equilibrium and consider dynamic heterogeneity of the adjustment process (Demetriades and Law, 2006) based on Maximum likelihood procedure.

The MG estimator suggested by Pesaran and Smith (1995) involves of estimating separate OLS regressions for each cross-sectional unit and compute the unweighted average of the individual country coefficients (e.g. Evans, 1997; Lee, Pesaran, and Smith, 1997; Demetriades and Law, 2006) that also allows for heterogeneity among the parameter estimates.

Though, MG estimated as shown by Pesaran and Smith (1995) yields consistent estimates of the average long-run coefficients, they however, caution that if the slope parameters are homogeneous across the group, MG estimator will be inconsistent, which may produce misleading estimate.

Alternatively, Pesaran *et al*. (1999) suggested PMG estimator. Unlike the MG procedure, the PMG approaches only impose restriction on the long-run coefficients, thereby allowing variation across the short-run coefficients. However, both MG and PMG estimations are based on the traditional autoregressive-distributed lag (ARDL) technique (Pesaran *et al*., 1999).

To select the appropriate model that can produce more reliable estimate among MG and PMG, the hypotheses for the existence of long-run homogeneity of slope parameters were examined by Hausman test. The null hypothesis for the Hausman test is that the differences in the coefficients estimated between PMG and MG estimators is not statistically significant, and PMG estimator is more efficient than the MG estimator (Pesaran *et al*., 1999).

Based on the Akaike information criterion (AIC), we impose the following ARDL (1,1,1,1,1,1,1,1,1) restrictions for environmental quality, FDI, energy consumption and other conditional control variables of our model.

Based on Pesaran *et al*. (1999), our unrestricted error correction on the basis of ARDL for environmental quality eqn. (4) can be written as

$$\begin{aligned}\Delta LE_{i,t} = \beta_0 + \delta_{10i}LFDI_{i,t} + \delta_{11i}LFDI_{i,t-1} + \delta_{20i}LEC_{i,t} \\ + \delta_{21i}LEC_{i,t-1} + \delta_{30i}X_{i,t_{i,t}} + \delta_{31i}X_{i,t-1} \\ + \lambda_i LE_{i,t-1} + \pi_{10}\mathrm{t} + \varepsilon_{i,t}\end{aligned} \tag{4}$$

The error correction reparamatization of eqn. (4) can be expressed as

$$\begin{aligned}\Delta LE_{i,t} = \Phi_i[LE_{i,t-1} - \beta_{1i}LFDI_{i,t} - \beta_{2i}LEC - \beta'_{3i}\ LX_{i,t} - \alpha_{0,i}] \\ - \delta_{11i}LFDI_{i,t-1} - \delta_{21i}LEC - \delta_{31i}X_{i,t_{i,t}} + \varepsilon_{i,t}\end{aligned} \tag{5}$$

Where the parameter, Φ_i is the error correction coefficient that measures the speed of adjustment of LE_{it} towards the long-run equilibrium following change in FDI inflows, energy consumption and other conditional regressors. β_{1i}, β_{2i} and β_{3i} are the long-run parameters while, δ_{11i}, δ_{21i} and δ_{31i} are the short-run coefficients relating past values of environmental pollution determinants.

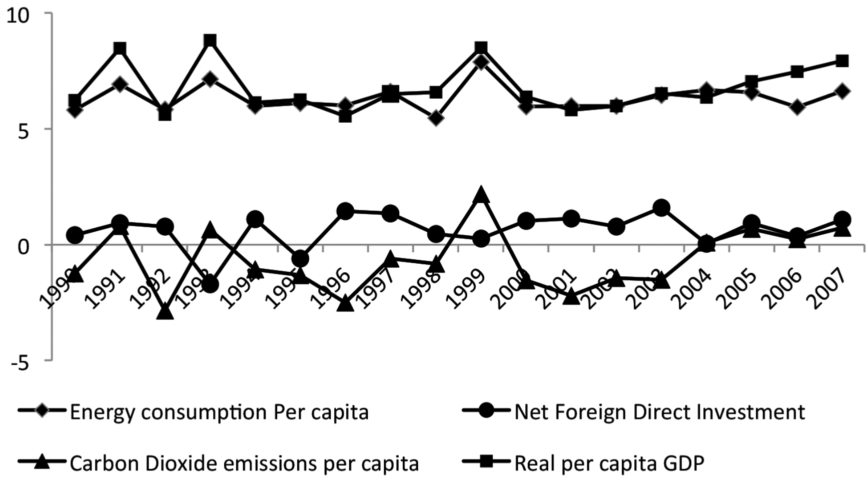
DATA

The analysis of this study makes use of macro panel data set of 19 selected African countries in the period 1990 – 2010. The start period is dictated based on the data availability of energy consumption for relatively long periods, while the end period is based on the availability of CO_2 emissions data. Data on aggregate FDI measured in Net inflows of FDI as a Share of GDP, energy consumption measured in kilogram of energy use per capita of oil equivalent and real per capita income (real GDP) in constant 2000 US dollars, which is used as a measure of the level of economic progress or development are all obtained from World Bank's online world development indicators (2014) and, if not available there, from the Penn world table version 8.0 Statistics (2013)[3]. Carbon dioxide emissions represented by CO_2 measures in metric tons per capita are also obtained from World Bank's online world development indicators (WDI, 2014). As for the relative income variable, it is expressed relative to the world average. The world average here, as in Antweiler *et al*. (2001) and Cole and Elliott (2003) refers to the average of the total income of all countries reported by the World Bank (online, 2014). Countries are selected based on the availability of all the data required for this analysis. The list of sample countries considered and, all variables measurements and definitions are presented in Appendix (Table A1 and A2).

The average annual data on carbon dioxide emissions, real GDP per capita, foreign direct investment and per capita energy consumption of African countries included in this study can be seen from Figure 1. It seems that almost all the variables on average show similar trends.

The fact that most of these data follow a similar trend appears to suggest that they have strong causal effects. This also indicates that a large portion of change in CO_2 emissions across the African region can be attributed to changes in the energy consumption, FDI and real per capita income.

[3] The net FDI inflows for some countries comprise a few negative values, and based on Osborne (2002), a constant positive value is added to the data set before log transformation so as to move the lowest value of the sample observation above.



Source: World Bank Online Database, 2014

Figure 1 Average annual log values of main study variables

EMPIRICAL RESULTS AND DISCUSSION OF FINDINGS

In this section, the estimated results for this study are presented and discussed. We first present the integration order of each variable include in our model in the context of unit root tests. The results are presented in Table 1.

Table 1 Panel unit root tests

	Levels			First difference		
	Im, Pesaran and Shin (IPS)	Levin, Lin, Chu (LLC)	Breitung	Im, Pesaran and Shin	Levin, Lin, Chu	Breitung
LE	–0.328	–2.725***	–1.899**	–15.121***	–16.59***	–8.348***
LY	–2.125**	–4.477***	5.628	–7.352***	–7.353***	–3.457***
LFDI	–6.063***	–3.745***	–0.058	–15.34***	–16.72***	–7.814***
LEC	–1.426*	–2.743***	0.630	–12.28***	–15.122***	–7.948***
LINV	–3.397***	–1.711**	–1.397*	–10.96***	–11.077***	–5.119***
LRY	16.76	14.59	15.01	–4.157***	–9.369***	–1.887**

Note: ** and *** indicate significance at 5% and 1% levels, respectively, which Signifies rejection of the unit root hypothesis. Optimum lag lengths are selected based on Schwartz information criterion (SIC).

To allow for more general specifications, both constant terms and trends are included in the unit root tests equations. The panel unit roots tests for IPS, except for carbon dioxide emissions and relative income, all the remaining variables are found to be stationary at their level. While for LLC, only relative income variables exhibit unit root property at a level. Using Breitung panel unit root tests, the results show that only carbon dioxide emission and domestic investment variables pass the stationarity test at level. However, when the unit root test was conducted for the whole variables at their first differences, as reported in Table 3, all the three tests support the hypothesis of stationarity property in all the variables across the countries considered. This suggests zero order integration I(0) in their first differences.

Since all the variables are either integrated of order zero, I(0) or one, I(1), PMG and MG estimators are now suitable to estimate the dynamic impact of energy consumption, FDI among other variables on environmental quality in Africa. The optimal lag was selected based on AIC, which is considered more suitable for sample lower than 60 cross-sectional observations (see Liew, 2004). Results are reported in models (1) and (2) in Table 2 below.

The result of the PMG and MG are reported in Table 2. From the estimated results, the Hausman test failed to reject the long –run homogeneity restrictions, suggesting that PMG methodology to be more efficient than MG estimates. Thus, FDI and energy consumption might have homogenous long – run environmental impact across Africa. For this reason and that of space our discussion will only focus on the PMG results.

Table 2 Estimation results for PMG and MG, ARDL (1, 1, 1, 1, 1, 1,1,1,1)

Dependent Variable: LE	Model 1		Model 2	
	MG	PMG	MG	PMG
Error correction terms	–0.803***	–0.321***	0.866***	–0.337***
	(0.109)	(0.077)	(0.287)	(0.083)
Long run coefficients				
LY	212.218	2.193***	–292.59	2.502***
	(212.983)	(0.651)	(383.47)	(0.665)
LY^2	–16.965	–0.226***	26.04	–0.2366***
	(16.968)	(0046)	(33.104)	(0.052)
LFDI	0.319	0.361***	–130.76	1.738**
	(0.526)	(0.097)	(142.10)	(0.818)

Table 2 (Cont.)

LINV	–0.070 (0.268)	–0.025 (0.038)	96.99 (116.94)	–0.7284 (0.818)
LEC	–0.431 (2.553)	2.160*** (0.167)	13.61** (7.156)	2.131*** (0.173)
LRY*LFDI	0.085 (0.169)	0.250*** (0.293)	–1.862 (1.975)	0.197*** (0.035)
LFDI*LEI			–7.00 (7.941)	0.103** (0.049)
LINV*LEI			5.631 (7.024)	0.044 (0.051)
Short run coefficients				
ΔLY	49.650 (126.925)	45.284 (130.624)	252.78 (152.11)	26.51 (112.97)
ΔLY^2	–1.405 (7.583)	–1.077 (7.727)	–18.09 (11.145)	–0.116 (6.829)
ΔFDI	–0.157 (0.211)	–0.009 (0.346)	–9.648 (27.438)	–0.224 (5.555)
ΔINV	0.104 (0.245)	0.085 (0.086)	12.34 (29.355)	–7.923 (12.606)
ΔLEC	0.431 (0.851)	1.125* (0.638)	1.028 (8.398)	2.842 (1.784)
Δ(LRY*LFDI)	–0.310 (0.203)	–0.132 (0.196)	–0.584 (0.743)	–0.147 (0.252)
Δ(LFDI*LEI)			–0.473 (1.697)	–0.031 (0.342)
Δ(LINV*LEI)			0.726 (1.719)	–0.049 (0.777)
No. of countries	19	19	19	19
No. of obs. Hausman tests	380 0.35 [0.9992]	380	399 0.02[1.00]	399

Note: ** and *** indicate significance at 5% and 1% levels, respectively. AIC criterion is used to choose the lag order. Figures in curly brackets are standard errors and those in square brackets are the null hypothesis for the non-systematic differences between estimated coefficient between PMG and MG estimators (i.e. Values for Prob>chi2).

As seen in Table 2, the significantly negative of the estimated error-correction coefficient or speed of adjustment of the PMG model suggest dynamic stability of its estimators. This indicates evidence of cointegration between energy consumption, FDI inflows, carbon dioxide and other conditional control variables, as well as, non-spurious convergence of any deviation from the long – run equilibrium among the variables in our model. However, the estimated result of PMG model found relative sluggishness in the adjustment process towards the long – run equilibrium.

Supporting the EKC hypothesis, the per capita income and its square are found to be significantly positive and negative respectively. For every 1% increase in the per capita GDP, carbon dioxide emissions per capita are increasing by 2.193%, while the same percent point increase in per capita output square makes pollution to fall by 0.226%. All the key variables of interest: the foreign direct investment, energy consumption and the pollution haven term are found to be significantly important in explaining greenhouse gases across the study countries. However, the estimated coefficient of the domestic investment appears to be not a significant determinant of carbon emissions across the sample countries.

We next consider including both domestic investment and foreign direct investment interactively with the energy intensity variable. This is to enable examining how energy intensive is the scale of economic activity across the sample countries. The estimated results, including these interaction tems are shown in model 2, Table 2.

As shown in table 2, model 2, adding these interaction terms did not show any significant difference effects of per capita income, FDI and energy consumption on pollution emissions across African countries. Regarding the long-run coefficient of the PMG estimation, the income level and income squared are found to be significantly positive and negative, respectively. This validates the EKC hypothesis. The coefficients of the key variables of interest, energy consumption and FDI inflows, are significant and positive in PMG specification. According to this estimate, one percent point increase in FDI inflows raises carbon emissions by about 1.74 percent, while the same percent point increase in energy consumption makes pollution rise by more than 2.00 percent. This impact may likely emanate from scale effect, that is, the previous effect of FDI – induced economic activity may have led to higher energy consumption. In order to investigate the composition effect of FDI inflows, we add interaction terms of the FDI inflows with energy intensity. This interaction term is to examine whether FDI inflows and energy use are jointly influencing pollution emissions in Africa.

As reported on Table 2, model 2, it is shown that for pollution emissions to rise by 1 percent, the energy intensity through the channel of foreign capital inflows has to increase by about 10 percent points. With regard to the environmental impact of domestic investment, our result finds no evidence for pollution–raising effect of aggregate domestic investment and neither its interaction with energy intensity leads to significant greenhouse gas increasing effect. The positive effect of FDI inflows on pollution emissions as against the domestic influence could be attributed to the foreign investment policies of the African countries that often substantially favour extractive industries[4]. Regarding the FDI inflows pollution haven argument in Africa, FDI inflows are interacted with relative income. The relative income differences seem to determine the composition effects of FDI inflows and, our estimate find evidence of pollution haven effect in Africa, which may be emanating from the scale effect of the foreign capital inflows.

We include quadratic terms of the FDI inflows to test whether more foreign investment inflows would significantly affect pollution generation across the sample countries. We find that the term is not a significant determinant of greenhouse gas (CO_2) emissions, and its inclusion also makes FDI to be insignificant. One possible reason is that the model may have been misspecified (and therefore, not reported).

CONCLUSIONS

The analysis of this study draws on recent developments that posit the impact of global economic integration of environmental quality. In both theoretical arguments and empirical investigations, it has been argued that foreign direct investment influences environmental quality. Empirical examination of environmental impact of FDI inflows, especially in the context of the Pollution haven argument received adequate attention with differing submissions.

This work has investigated the determinants of FDI-induced environmental composition effect. Specifically, this study examined whether structural changes of greenhouse gases associated with FDI inflows emanate as a result of differences in environmental regulations between Africa and its foreign investment partners. Our empirical investigation provides us with conclusions that both the main variables of interest, energy consumption and FDI inflows have a positive scale effect of environmental degradation in Africa. The result also found an indirect scale effect through the channel of FDI inflows that perhaps relates to structural

[4] Due to unavailability of sectoral data that could have enable us to decouple the effects of energy consumption and its intensity in FDI inflows , our analysis is based on their overall effect. As such, interpretation of our results should be made with caution.

change associated to increase in income as a result of more foreign capital inflows that could improve the societal standard of living and are therefore (perhaps for some time) reluctant to pursue stringent pollution control. This could also be possible via long-run technological spillover effect from environmentally friendly technologies of the multinationals as a result of more openness to FDI inflows. Our findings also provide evidence for environmental regulation effect and, with caution, we conclude that the pollution haven hypothesis do exist in the African countries considered by this study.

Finally, since the inflows of FDI are known to be an essential determinant of national output and, as shown from our estimate that at higher income environmental pollution tends to decline, then more FDI inflows too can be of greater benefit to environmental quality in Africa. This indicates that African governments should integrate environmental concerns into their foreign investment and energy policies. There is a need for the government in the region to direct their foreign investment policies towards economic diversification that can be oriented towards improving energy efficiency. This could be realized by encouraging inflows of foreign multinationals that abide by global standard and export up-to-date and efficient technology that can facilitate speedy transfer of environmental friendly technologies to the continent. This in a way is capable of lessening their greenhouse gas effect, thereby improving energy efficiency for sustainable economic progress in the continent.

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APPENDIX

Table A1 List of sample countries

Benin	Kenya	Tanzania
Botswana	Mozambique	Togo
Cameroun	Nigeria	Tunisia
Congo DR	Morocco	Zambia
Egypt, Arab Rep.	Senegal	Zimbabwe
Garbon	South Africa	
Ghana	Sudan	

Table A2 Variables definition

Variables	Definition	Unit measurement	Source
E	Environmental stressors: Emissions of CO_2	CO_2 (Metric tons per capita)	World Bank (Online, 2014)
FDI	Foreign direct investment	Net inflows of FDI as a Share of GDP	World Bank (Online, 2014)
INV	Domestic investment	Gross fixed capital formation as a share of GDP	World Bank (Online, 2014)
EC	Energy consumption	Kilogram of energy use per capita of oil equivalent	World Bank (Online, 2014)
Y	Per capita income (measured by real GDP)	Constant 2000 US dollars	World Bank (Online, 2014)
RY	Relative income “expressed relative to the world average (divided by the world average). World averages are calculated as the average of all countries for whom data are reported (online) in World Bank (2014)”	Constant 2000 US dollars	World Bank (Online, 2014)
LEI	Energy intensity in the national production (total energy use per unit of GDP)	Kilogram of energy use per unit of GDP	World Bank (Online, 2014)