Foreign Direct Investment, Economic Growth and Environmental Quality in Sub-Saharan Africa: A Dynamic Model Analysis

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Abstract

The paper investigates the dynamic interactions among the inflow of foreign direct investment, economic growth and environmental quality of the countries in Sub-Saharan Africa (SSA). It seeks to examine the environmental implications of the inflow of foreign direct investment and economic growth of the countries in the sub-region. The dynamic interaction was examined through Panel Vector Autoregressive (PVAR) and Panel Vector Error Correction (PVEC) methodologies on a sample of thirty-three SSA countries. Panel unit root test and panel cointegration test were conducted to determine the degree of stationarity of the variables and long–run relationship among our variables of interest respectively. The results of the empirical analysis showed that dynamic interactions exist among foreign direct investment, economic growth and environmental quality, with the magnitude of influence on one another between 13.1% and 32.8%. The paper suggests that governments of Sub–Saharan African countries should strike a balance between investment friendly policies and environmental protection policies such that foreign direct investment that will be attracted into the region will be those that will improve the environmental quality of the countries in the region.

Keywords: Dynamic Interactions, Panel Vector Autoregressive, Panel Vector Error Correction, Cointegration, Impulse-Response, Variance Decomposition.

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1 Introduction

The nexus of interaction between Foreign Direct Investment (FDI) and economic growth leaves behind the important issue of environmental quality. Given the capital deficient nature of Less Developed Countries and the benefits accruable from the activities of Multinational Corporations (MNCs), FDI is seen to be essential for growth and development in the region. There is therefore a shift of emphasis by governments in Sub-Saharan African Countries in taking steps and efforts to integrate their economies with the rest of the world in order to accelerate capital inflow (FDI) in their respective countries. This aims at generating economic recovery in the region in order to keep African countries on the path of achieving the Millennium Development Goals (MDGs), especially in the area of sustainable development.

Environmental condition of the recipient country is considered to be very important a factor in driving FDI to any country. It determines the magnitude of the inflow of FDI that a particular country can enjoy. Therefore, the governments of developing countries have a tendency of undermining their environmental regulations through relaxed or non-enforced regulation in order to attract foreign investment. More than ever before, more firms in numerous industries and in many countries are expanding abroad through FDI. This is noticed in the increased magnitude of FDI into sub-Saharan Africa countries within the past few years. On the other hand, FDI by foreign companies in most sub-Saharan African Countries has a traditional reliance on natural resource use and extraction, particularly agriculture, mineral and oil production. The past decades therefore has also seen all trends of environmental degradation accelerate e.g. greenhouse gas emission, deforestation, loss of biodiversity among others. Such patterns of environmental destruction have been driven by increased economic activities, of which FDI has become an increasingly significant contributor. According to He (2005), FDI can generate new growth, new structural efficiencies and make larger investments in environmental protection possible; but, may also lead to increased production and consumption of polluting goods or expand industrial activities and thus, increase pollution emissions. This invariably reveals dynamic interactions among the specified variables of this research work, with a particular reference to countries in sub-Saharan Africa.

Over the few past decades, the raging and contentious issue in the environmental economics literature that has generated a vast amount of empirical research and debate centers on causal relationship between growth and environment (Ajide and Oyinlola, 2010). This debate appears fairly settled in the context of the developed economies as there has been a large body of research published in this regard, but has just stimulated renewed interests in the developing countries, most especially sub-Saharan Africa. Many of the existing literature on the interrelationship among environmental quality, foreign direct investment and economic growth had only limited themselves to single country analysis while most of the cross-country analyses are credited to the developed countries. Studies that emerged on this relationship in developing countries were focused on the Asian countries. This is a gap that this paper attempts to fill. In this study, we examine dynamic interactions among environmental quality, foreign direct investment and economic growth in the sub-Saharan Africa, using Panel Vector Autoregressive and Panel Vector Error Correction approaches.

The remainder of the paper is organized in the following ways. Section 2 presents a review of theoretical issues. Section 3 describes the methodology adopted in the paper. Section 4 presents the empirical results and section 5 concludes the paper.

2 Theoretical Issues

The relevant literature on FDI, economic growth and environmental quality shows three main strands. The first strand links FDI and economic growth, where FDI is shown to boost the economic growth of the host country. It is argued that FDI increases capital accumulation in the recipient economy, improved efficiency of locally owned host country firms via contract and demonstration effects, and their exposure to fierce competition, technological change, and human capital augmentation and increased exports. It is often claimed that FDI is an important source of capital which complements domestic investment, creates new jobs opportunities and is in most cases related to the enhancement of technology transfer, which of course boosts economic growth (Akinlo, 2004). However, the extent to which FDI contributes to growth depends on the economic and social condition or in short, the quality of environment of the recipient country (Buckley, Clegg, Wang and Cross, 2002). Some empirical studies have found evidence to support that FDI stimulates economic growth (Dees, 1998; De Mello, 1997; Blomstrom *et al*, 1994; e.t.c.). Dees (1998) submits that FDI has been found to be important in explaining China's economic growth, so also is De Mello (1997) who presents a positive correlation for selected Latin American countries. Blomstrom *et al*. (1994) report that FDI exerts a positive effect on economic growth, but that there seems to be a threshold level of income above which FDI has positive effect on economic growth and below which it does not. Ayanwale (2007) reveals that non-extractive FDI in Nigeria contributes positively to economic growth, but the overall effect is positively insignificant. Nuzhat (2011) finds that FDI positively influence the economic growth by stimulating domestic investment, increasing human capital formation and facilitating the technology transfer in the host countries. But a number of studies have generally reported an insignificant or negative effect of FDI on growth in developing host countries. FDI may have negative effect on the growth prospect of the recipient economy if they give rise to a substantial reverse flows in the form of remittances of profits, particularly if resources are remitted through transfer pricing and dividends and/or if the transnational corporations (TNCs) obtain substantial or other concessions from the host country. For instance, Singh (1988) finds FDI penetration variable to have a little or no consequences for economic or industrial growth in a sample of 73 developing countries. In the same way, Hien (1992) reports an insignificant effect of FDI inflows on medium term economic growth of per capita income for a sample of 41 developing countries. Also, Herzer *et al.* (2008) consider FDI led growth hypotheses for 28 developing countries by applying Engle Granger Cointegration and Error Correction Model for short run dynamics. They find neither long run nor short run relationship between FDI and economic growth of most countries.

The second strand links FDI and environmental quality which is referred to as the FDI - Environment nexus. In order to attract foreign investment for better economic performance, the governments of developing countries have a tendency to undermine environmental concerns through relaxed or non-enforced regulation, thus confirming the Pollution Haven Hypothesis in such countries. This makes Multinational corporations to shift their operations to the developing countries to take advantage of lower production cost which is known as Industrial Flight Hypothesis. The existence of these hypotheses leads to excessive pollution and degradation in environmental standard of the host countries. Xing and Kolstad (2002) and He (2006) confirm that foreign firms operate in developing countries where environmental rules are either non-existent or not enforced, which lead to excessive pollution and degradation in environmental standard of the host countries. Boqiong and Jianguo (2010) consider the impact of FDI on environment in host countries (China) with the construction of a simultaneous system (3SLS) with data of 28 provinces in China with a time frame of 1992 to 2008. The results show that the environmental effect of FDI is positive, which means that FDI increases pollution emission. Whereas, Zarsky (1999) opines that FDI through foreign companies use better management practices and advanced technologies that result in clean environment in host countries.

The third strand considers the link between economic growth and the environment. The literature suggests that environmental pollution levels increase as a country develops, that is economic growth brings about reduction in environmental quality. But when income rises beyond a critical point, pollution levels begin to fall. This is hypothesized in Environmental Kuznets Curve. This hypothesis was first proposed and tested by Grossman and Krueger (1991), followed up by Selden and Song (1994), Suri and Chapman (1998) and Agras and Chapman (1999). One of the recent works by Apergis and Payne (2010) found energy consumption to be positively linked with CO_2 emissions in six Central American economies. But Lean and Payne (2010), considering the issue of causality, found long-run causality running from energy consumption and CO_2 emissions to economic growth while in the short-run, energy consumption causes CO_2 emissions.

The linkage of environmental quality with FDI and economic growth from the three strands reveals a dynamic interaction as any of the variables can drive the others. A lot of research interests have been shown on the relationship but most of such works are not situated in Africa. Beak and Koo (2009) in their study using the cointegration analysis and a vector error-correction model to examine the short-run and long-run relationships among foreign direct investment, economic growth, and the environment in China and India, find out that FDI inflow plays a pivotal role in determining the short-run and long-run movement of economic growth through capital accumulation and technical spillovers in the two countries. However, FDI inflow in both countries is found to have a detrimental effect on environmental quality in both the short-run and long-run. Also, Lee (2010) finds a long run relationship between economic growth, foreign direct investment and energy pollutants in Malaysia if FDI is treated as dependent variable. In the same vein, Pao and Tsai (2011) study the effect of economic growth and FDI on environmental degradation using data of BRIC countries by applying panel Cointegration. Their results support long run relationship between FDI and energy pollutants and economic growth. Kim and Beak (2011) shows that economic growth lowers the growth of energy emissions in developed world but environmental quality is deteriorating during economic growth process in developing economies. He uses ARDL bounds testing approach on environmental consequences of economic growth. He adds that a rising demand for energy is a major contributor to energy emission and FDI has minimal effect on CO_2 emission. Ajide and Oyinlola (2010) in the case of Nigeria, find significant negative impacts of FDI on per capita carbon emission (CO_2) while other financial developments indicators has a significant and positive impact on carbon emission. This is a single country analysis in Africa and does not consider interaction since only two variables are dominant in the study. Posu (2014) investigates the interrelationships among economic liberalization, economic growth, and environmental quality in Nigeria between 1970 and 2012. This study considers directions of causality among the variables and finds causality running from trade intensity to environmental quality; FDI to environmental quality; Gross Domestic Product (GDP) per capita to environmental quality; and GDP per capita to FDI. The study is country-specific and does not consider dynamic interaction among the specified variables.

Evidences from various research works both at country – specific and cross – country level reveal that there is no consensus on the dynamic interaction among foreign direct investment, economic growth and environmental quality. The literature that examine SSA sub-region are also sparse. This study employs Panel methods which allow for more robust estimates by utilizing variations between countries as well as variations over time. The findings of this study will guide the policy makers of the countries in the region in adopting policies that will attract FDI to propel economic prosperity and improve environmental quality.

3. Methodology

3.1 Sources of data and Description of Variables

The annual time series data for 33 countries in the SSA over the period 1980 to 2013 were sourced from World Development Indicators. The variables of interest for the study include Foreign Direct Investment, Real Per Capita Gross Domestic Product, Pollution Indicator (Carbon Dioxide Emission) and Energy Consumption. The selected countries are: Angola, Benin, Botswana, Cameroon, Chad, Congo, Democratic Republic of Congo, Cote d'Ivoire, Equatorial Guinea, Ethiopia, Gabon, Ghana, Guinea, Kenya, Liberia, Madagascar, Malawi, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Senegal, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia and Zimbabwe. For the purpose of estimation, the variables of interest are defined in the table below:

Table 1: Definition of Variables

Variables	Definition
GDP (rpy)	The real per capita growth rate was used. This is real gross domestic product divided by midyear population.
FDI (fdi)	This is net FDI inflow as a share of GDP i.e. net FDI inflow per capita. This series shows net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors, and is divided by GDP.
Carbon Dioxide Emissions(CO_2)	These are carbon dioxide emissions stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.
Energy Consumption(EGC)	This refers to the use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.

Note: All monetary measures are in U.S. dollars.

3.2 Methodological Framework

The study is interested in both the short run and long-run dynamic interactions among economic growth, foreign direct investment and environmental quality as well as thier equilibrium relationship; therefore, the baseline models for this study are Panel Vector Autoregressive (PVAR) and Panel Vector Error Correction Mechanism (PVEC) estimations. According to Adrangi and Allender (1998), VAR models are adjudged as the best method for investigating dynamic interactions and shock transmission among variables because they provide information on impulse responses. The VAR models make all variables to interact in the regression with past values of one another without any theoretical structure on the estimators. The VAR models are dynamic and as such can explain the dynamic structure of time series better than the static OLS estimation method. It also allow for the analysis of the interrelationships among various variables with stronger effects (Choi *et al*, 2010). The PVAR and PVEC models are specified differently as below.

3.2.1 Panel VAR Model Specification

In adopting the panel VAR model framework for this study, we consider the three variables of interest in our equation. Energy consumption (EGC) is introduced as a control variable to trace the crowd-in or complementary effect of carbon emission density (CO_2) of FDI and economic growth. We then adopt Four-Variable PVAR model to explore the dynamic interaction among the logs of real per capita income (rpy), net inflow of FDI (fdi), carbon emission density (CO_2) and energy consumption (EGC) in the PVAR models. The model used is an unrestricted VAR model that includes cointegrating relationships among variables of the model to capture the long-run characteristics of the variables.

The vector (y_{it}) of endogenous variables included in the reduced-form PVAR representation is expressed as:

$$Y_{i,t} = \theta_0 + \theta(l)Y_{i,t} + \mu_i + \varepsilon_{i,t} \tag{1}$$

Where l =1, 2, 3,…….n; t = 1, 2, 3, …….Ti;

Y_{it} is a (4x1) of endogenous variables; θ_0 is a (4x1) vector of constant, $\theta(l)$ is a matrix polynomial for the lag operator of considered variables (l) defined as

$$\theta(l) = \beta_1 l + \beta_2 l^2 + \beta_3 l^3 + \dots\dots\dots.. + \beta_\rho l^\rho \tag{2}$$

β_i is a (4x4) matrix of coefficients, v_i is a matrix of country specific fixed effects and ε_{it} is a (4x1) vector of normality, identically distributed disturbances. It is assumed serially and mutually uncorrelated structural disturbances. Therefore, the structural unrestricted PVAR model for this study is as specified. Explicitly, the components of equation 2 can be defined as

$$Y_{i,t} = \begin{bmatrix} Lrpy_{i,t} \\ Lfdi_{i,t} \\ LCO_{2\,i,t} \\ LEGC_{i,t} \end{bmatrix}, \theta_0 = \begin{bmatrix} \lambda Lrpy \\ \lambda Lfdi \\ \lambda LCO_2 \\ \lambda LEGC \end{bmatrix}, \theta(L)Y_{i,t} = \begin{bmatrix} \beta_{i,t} & Y_{i,t} & \alpha_{i,t} \\ \beta_{i,t} & Y_{i,t} & \alpha_{i,t} \\ \beta_{i,t} & Y_{i,t} & \alpha_{i,t} \\ \beta_{i,t} & Y_{i,t} & \alpha_{i,t} \end{bmatrix} \begin{bmatrix} Lrpy_{i,t} \\ Lfdi_{i,t} \\ LCO_{2\,i,t} \\ LEGC_{i,t} \end{bmatrix} + \varepsilon_{i,t} = \begin{bmatrix} \varepsilon Lrpy_{i,t} \\ \varepsilon Lfdi_{i,t} \\ \varepsilon LCO_{2\,i,t} \\ \varepsilon LEGC_{i,t} \end{bmatrix} \tag{3}$$

Where:

$Lrpy_{i,t}$ is log of real per capita income at period t across the countries;

$Lfdi_{i,t}$ is the net inflow of foreign direct investment as a percentage of GDP at period t, across the countries;

$LCO_{2\,i,t}$ is the log of carbon emission per capita at period t across the countries; and

$LEGC_{i,t}$ is the log of energy consumption per capita at period t, across the countries.

The system of equations can now be written in a single equation form as:

$$\begin{bmatrix} Lrpy_{i,t} \\ Lfdi_{i,t} \\ LCO_{2\,i,t} \\ LEGC_{i,t} \end{bmatrix} = \begin{bmatrix} \theta_0 \\ \theta_0 \\ \theta_0 \\ \theta_0 \end{bmatrix} + \begin{bmatrix} \beta_{i,t} & Y_{i,t} & \alpha_{i,t} & \lambda_{i,t} \\ \beta_{i,t} & Y_{it} & \alpha_{i,t} & \lambda_{i,t} \\ \beta_{i,t} & Y_{i,t} & \alpha_{i,t} & \lambda_{i,t} \\ \beta_{i,t} & Y_{i,t} & \alpha_{i,t} & \lambda_{i,t} \end{bmatrix} \begin{bmatrix} Lrpy_{i,t-p} \\ Lfdi_{i,t-p} \\ LCO_{2\,i,t-p} \\ LEGC_{i,t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon Lrpy_{i,t} \\ \varepsilon Lfdi_{i,t} \\ \varepsilon LCO_{2\,i,t} \\ \varepsilon LEGC_{i,t} \end{bmatrix} \tag{4}$$

This equation 4 was estimated through PVAR to verify the dynamic interactions among economic growth *(rpy),* foreign direct investment *(fdi)* and environmental quality *(CO_2)* for the panel of thirty-three selected SSA countries.

3.2.2 Panel Vector Error Correction (PVEC) Model Specification

A natural progression from a VAR representation in section 3.2.1 is the VEC model especially when the variables of interest are not stationary at their levels and are cointegrated. There is a general contention in econometrics literature that a cointegrated VAR with non-stationary time series is best estimated with VEC model to determine the short-run dynamic interaction among set of macroeconomic variables from the cointegrating (long-run) equation. At this occasion, a Vector Error Correction Model (VECM) leads to a better understanding of the nature of any non-stationarity among the different variables in the series as well as their long-run equilibrium. A Vector Error Correction Model (VECM) improves longer term forecasting error over an unconstrained model (Sreedharan, 2004). A dynamic model using the Vector Error Correction Model (VECM) representation of Engle and Granger (1987) is applied with the insight that even though endogenous variables ($Y_{i,t}$) are non-stationary, they might be cointegrated. The major distinction between VAR and VEC models is the incorporation of error correction mechanism (ECM) term that tries to explain the speed of convergence to, or divergence from, a long-run equilibrium from a short-run disequilibrium since the cointegrated times series could not converge to their individual mean in the long-run (that is, non-stationary).

The series are found to exhibit at least one-cointegrating equation, we then proceed to estimate a vector error correction (VEC) model with the incorporation of an error correction mechanism term from the estimated VAR model. The Panel VECM of ($Y_{i,t}$) is written as:

$$\Delta yt = \alpha + \sum_{i=1}^{p=1} \phi_i \, \Delta y_{i,t} + \Pi y_{i,t-1} + \varepsilon_t \qquad (5)$$

Where Δ is the differencing operator, such that $\Delta yt = y_{i,t} - y_{i,t-1}$; $y_{i,t}$ is an (nx1) column vector of endogenous variables, α is an (nx1) vector of constant terms, ϕ and π represent coefficient matrices. The coefficient matrix π is known as the impact matrix, and it contains information about the long-run relationships.

The Vector Error Correction version pertaining to the four variables incorporated in our model for the study is expressed below:

$$\Delta Lrpy_{t-1} = \alpha_1 + \sum_{i=1}^{p} \beta_{j1} \, \Delta Lrpy_{t-1} + \sum_{i=1}^{p} \gamma_{j1} \, \Delta LFdi_{t-1} + \sum_{i=1}^{p} \theta_{j1} \, \Delta LCO_{2t-1} + \sum_{i=1}^{p} \alpha_{j1} \, \Delta LEGC_{t-1} + K_1 ECM_{t-1} + \varepsilon_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6$$

$$\Delta LFdi_{t-1} = \alpha_2 + \sum_{i=1}^{p} \beta_{j2} \, \Delta Lrpy_{t-1} + \sum_{i=1}^{p} \gamma_{j2} \, \Delta Lfdi_{t-1} + \sum_{i=1}^{p} \theta_{j2} \, \Delta LCO_{2t-1} + \sum_{i=1}^{p} \alpha_{j2} \, \Delta LEGC_{t-1} + K_2 ECM_{t-1} + \varepsilon_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 7$$

$$\Delta LCO_{2t-1} = \alpha_3 + \sum_{i=1}^{p} \beta_{j3} \, \Delta Lrpy_{t-1} + \sum_{i=1}^{p} \gamma_{j3} \, \Delta LFdi_{t-1} + \sum_{i=1}^{p} \theta_{j3} \, \Delta LCO_{2t-1} + \sum_{i=1}^{p} \alpha_{j3} \, \Delta LEGC_{t-1} + K_3 ECM_{t-1} + \varepsilon_3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 8$$

$$\Delta LEG_{t-1} = \alpha_4 + \sum_{i=1}^{p} \beta_{j4} \, \Delta Lrpy_{t-1} + \sum_{i=1}^{p} \gamma_{j4} \, \Delta LFdi_{t-1} + \sum_{i=1}^{p} \theta_{j4} \, \Delta LCO_{2t-1} + \sum_{i=1}^{p} \alpha_{j4} \, \Delta LEGC_{t-1} + K_3 ECM_{t-1} + \varepsilon_4 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 9$$

Where ECM_{t-1} is the error correction term and ε_t is the mutually uncorrelated white noise residual. The size and statistical significance of the coefficient of the error correction term in each model measures the tendencies of each variable to return to the equilibrium. A significant coefficient implies that past equilibrium errors play a role in determining the current outcomes. The short-run dynamics are captured through the individual coefficients of the difference terms.

The components of vector error correction models in equation 6 to 9 can be expressed explicitly in matrix form as:

$$\begin{bmatrix} Lrpy_{i,t} \\ Lfdi_{i,t} \\ LCO_{2\,i,t} \\ LEGC_{i,t} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{bmatrix} + \begin{bmatrix} \mathrm{B}_{j1} & \Upsilon_{j1} & \Theta_{j1} & \lambda_{j1} \\ \mathrm{B}_{j2} & \Upsilon_{j2} & \Theta_{j2} & \lambda_{j2} \\ \mathrm{B}_{j3} & \Upsilon_{j3} & \Theta_{j3} & \lambda_{j3} \\ \mathrm{B}_{j4} & \Upsilon_{j4} & \Theta_{j4} & \lambda_{j4} \end{bmatrix} \begin{bmatrix} Lrpy_{t-1} \\ Lfdi_{t-1} \\ LCO_{2\,t-1} \\ LEGC_{t-1} \end{bmatrix} + \begin{bmatrix} K_1 \\ K_2 \\ K_3 \\ K_4 \end{bmatrix} \begin{bmatrix} ECM_{t-1} \\ ECM_{t-1} \\ ECM_{t-1} \\ ECM_{t-1} \end{bmatrix} + \begin{bmatrix} \mu Lrpy \\ \mu Lfdi \\ \mu LCO_2 \\ \mu LEGC \end{bmatrix} \quad (10)$$

Hence, equation 10 was estimated through panel vector error correction method to verify the dynamic interactions among economic growth, foreign direct investment and environmental quality in the selected countries of SSA.

3.3 Techniques of Estimation

3.3.1 Time Series Property and Cointegration

It has been shown in a number of theoretical literature that the statistical properties of regression analysis using non-stationarity time series data are likely to be spurious (Philips and Perron, 1988; Yinusa, 2004; Yinusa and Akinlo, 2008; and Adebiyi, 2007). However, Engle and Granger (1987) show that, even in the case that all the variables in a model are non-stationary, it is possible for a linear combination of integrated variables to be stationary. In this case, the variables are said to be cointegrated and the problem of spurious regression does not arise. As a result, the first requirement for Cointegration analysis is that the selected variables must be non-stationary. To address this, unit root test was carried out to determine how many times a variable should be differenced to attain stationarity. This informs the use of Panel Unit Root Tests for this study.

Furthermore, co-integration techniques were applied to examine the existence of long run relationships among the variables. To achieve this, Johansen Fisher Panel Cointegration test was employed to capture the dynamic and heterogeneous nature of the data. The cointegration test was applied using selected lag-lengths based on minimum AIC and SIC in the VAR.

3.3.2: Error Correction Analysis Procedure

Having established Cointegration among environmental quality, FDI and economic growth in the selected countries of SSA, there is a need to avoid miss-interpretation of cointegration results. It is essential to deduce and clarify that the existence of cointegrating equations does not signify that there is long-run equilibrium among different combinations or pairs of included variables in the VAR system without any theoretical basis. Therefore, this can be investigated by examining the short run and long run relationships among the set of variables in a Vector Error Correction Model (VECM). This is as a result of the general contention in econometrics literature that a cointegrated non-stationary series in a VAR model is best examined under VEC model in order to determine the long-run cointegrating relationship, short run adjustment mechanism to equilibrium and speed of adjustment.

3.3.3 Impulse Response Function and the Variance Decomposition

It has been pointed out in the literature that individual short run adjustment co-efficients from the error correction model are difficult to interpret in the case of the vector auto-regressive model. In view of this, the dynamic properties of the model are analysed by examining the impulse response function (IRF) and the variance decompositions (VD). The impulse response function traces the response of one endogenous variable to one-standard shock in another variable, which is considered a dynamic multiplier. It traces the dynamic responses to the effect of shock in one variable upon itself and on all other variables; it is a tool that portrays the expected path over time of the variable to shocks in the innovations. The impulse response function indicated the direction and size of the effect of a one standard deviation (SD) shock to one variable on the other system variables over time. The impulse response functions are responses of all variables in the model to a one unit structural shock to one variable in the model. The IRF are plotted on the Y-axis with the period from the initial shock on the X-axis. The interpretation would rely more heavily on the signs of the estimate because the magnitude shows the statistical influence while signs provided the desired economic content for the impact.

The forecast error variance decomposition measures the proportion of movement in a sequence attributed to its shock to distinguish it from movement attributable to shocks to another variable. In the FEVD analyse, the proportion of Y variance due to Z shock is measured. It shows the explanatory contributions of the shock to innovation of the included variables. These were used to analysis the dynamic interactions among FDI, economic growth and environmental quality in the selected countries of SSA from 1980 to 2013.

4. Estimated Results and Discussion

The elucidation of the econometric results proceeds in three stages. The stationarity properties of the data as examined by panel unit root test were presented; followed by the results of panel cointegration tests which check the existence of long run equilibrium relationship. Finally, we explicate the dynamic interactions among foreign direct investment, economic growth and environmental quality in sub-Saharan African countries.

4.1 Results from Panel Unit Root Tests

The primary requirement for cointegration and dynamic interaction is to check the stationary properties of the time series data. The study applied panel unit root tests to all the variables in the study for thirty–three countries of SSA for the periods 1980-2013. Table 2 below presents the results of unit root tests at the panel level obtained from Levin, Lin and Chu, Im, Pesaran and Shin, P.P. Fisher and ADF Fisher.

Table 2: Panel Unit Root Test Results

Variable	Levin, Lin and Chu (t-stat)	Im, Pesaran & Shin(W-sta)	ADF Fisher (Chi-sq)	P.P. Fisher (Chi-sq)	Level of Stationarity
GDP*	-17.9437	-18.7501	479.082	545.139	1
GDP**	-19.3889	-20.3712	487.189	736.901	1
FDI*	-2.12136	-6.16128	256.176	269.957	0
FDI **	-6.02938	-8.27837	270.086	279.372	0
CO2 *	-28.5274	-28.8380	786.925	872.749	1
CO2**	-28.1323	-29.9246	802.112	1490.75	1
EGC*	-25.2586	-25.4515	515.250	541.492	1
EGC**	-22.8744	-24.3618	496.830	742.760	1

** Intercept; ** Linear Deterministic Trend; 0-Stationary at Level; 1- Stationary at first difference.*

The results showed that almost all the variables tested were non-stationary at their levels ($p < 0.05$), except foreign direct investment. This indicates that the incorporated time series variables are unstable and non-mean reverting and this might render the model estimations structurally unstable at levels. Stationarity was only induced to three of the variables after first difference. This implies that those panel series are I (1), that is, they are integrated of order one. It therefore becomes econometrically reasonable to conduct the panel cointegration test thereafter.

4.2 Results from Panel Cointegration Tests

Following the findings in Table 2 that stationarity was induced to almost all the variables of interest after first difference, hence the Cointegration test statistics to ascertain if long run relationship exists among the variables of concern in the specified models. To achieve this, Johansen Fisher Panel Cointegration test was employed since it is dynamic and heterogeneous in nature. This is relevant in this case since this study considers the dynamic interaction among environmental quality, FDI and economic growth in the selected countries of SSA. The summaries of results of the Johansen Fisher Panel Cointegration test for the selected SSA countries are shown in Table 3 below:

Table 3: Johansen Fisher Panel Cointegration Test Results

R	Max. Eigen Statistic		Trace Statistic	
R=0	393.3***	0.0000	466.6***	0.0000
R≤1	159.5***	0.0000	186.0***	0.0000
R≤2	73.26***	0.0005	80.56***	0.0001
R≤3	52.00**	0.0467	52.00**	0.0467

***, ** indicate 1% and 5% level of significance.

Source: Author's Computation

Evidence from co-integration tests results indicates rejection of null hypothesis of no cointegration among the variables at 1% and 5% significance levels for the model specifications. The result indicates that at least one co-integrating vector exists among the variables in the model. This implies that the variables are cointegrated, suggesting that there is presence of long run feedback effects on the short run dynamism of the specified model in the selected countries of SSA for the period under review. The implication of the existence of co-integration is that any of the variables can be targeted as a policy variable to bring about the desired changes in other variables in the model. More importantly, it means that changes in any dependent variable are also a function of the degree of the disequilibrium in the co-integrating relationship, which is captured by the error-correction term. This is considered in the next section.

4.3 Dynamic Interaction: Evidence from Panel Vector Error Correction (PVEC) Analysis

Having established cointegration among environmental quality, FDI and economic growth in the selected countries of SSA, this section examines the dynamic interaction among environmental quality, the inflow of FDI and economic growth in SSA for the period under review. This is investigated by examining the short run and long run relationships among the set of variables in a Vector Error Correction Model (VECM). The Johansen Cointegration revealed that the incorporated time series are found to be cointegrated at rank of 4. Therefore, the VEC model is estimated at lag 4 to examine the possible causal environmental effects of FDI and economic growth in the selected countries of SSA. It is noted as been pointed out in the literature that individual co-efficients from Panel Vector Error Correction Model are difficult to interpret in the case of the vector autoregressive model. Therefore, impulse response functions and variance decompositions are later on considered to examine the dynamic properties of the variables in the specified model. The results of the PVEC estimates are presented in Table 4.

Table 4: Results of Estimated Vector Error Correction Model

Vector Error Correction Estimates				
Cointegrating Eq:	CointEq1			
LOG(C02(-1))	1.000000			
LOG(RPY(-1))	22.19671 [1.00403]			
LOG(EGC(-1))	64.29119 [1.61229]			
FDI(-1)	32.58985 [5.53283]			
C	-345.5497			
Error Correction:	D(LOG(C02))	D(LOG(RPY))	D(LOG(EGC))	D(FDI)
CointEq1	0.000150 [1.18786]	7.87E-05 [3.84949]	1.75E-05 [0.88569]	-0.006456 [-4.12703]
R-squared	0.199560	0.249131	0.054180	0.302224
Adj. R-squared	0.171846	0.223134	0.021433	0.278065
F-statistic	7.200746	9.582893	1.654487	12.50965

Figures in parentheses are t-statistics

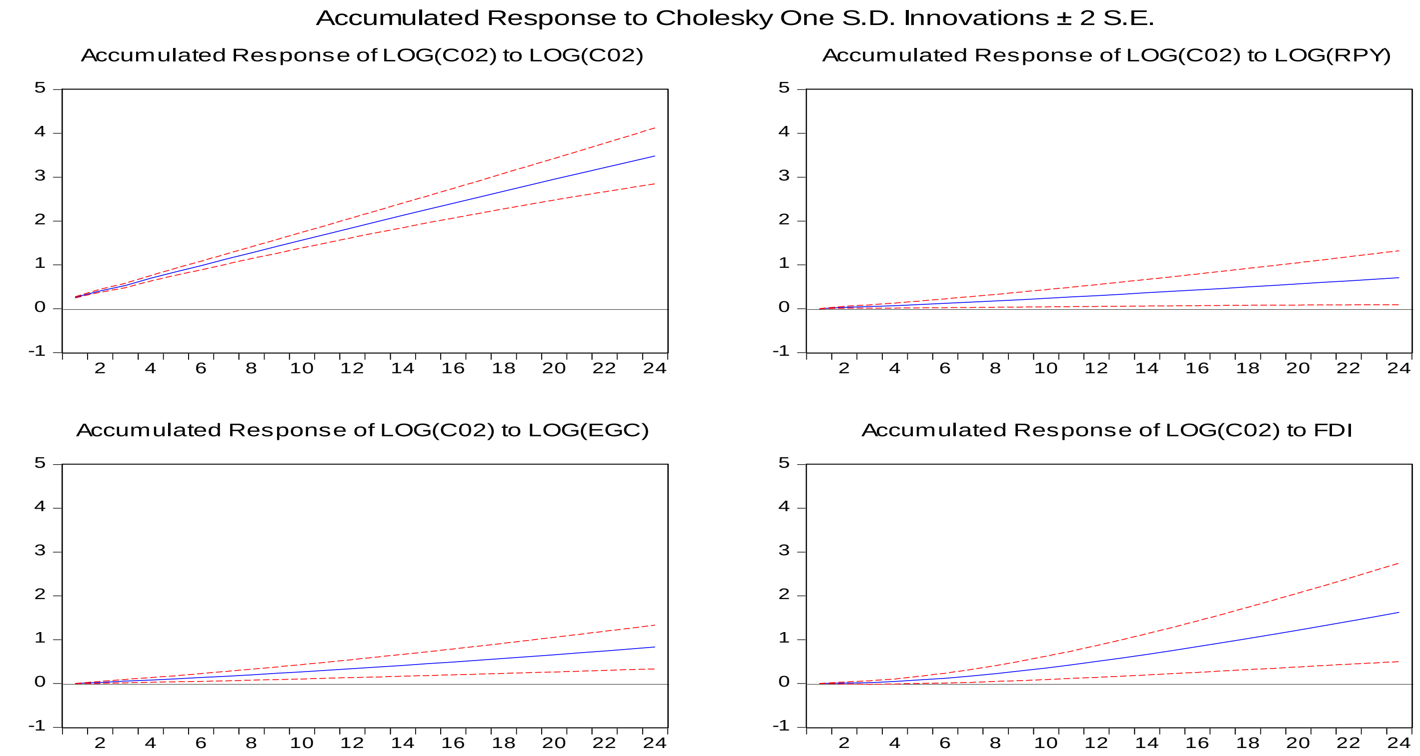
From Table 4, the long-run estimated model revealed that the effect of FDI inflow and real per capita income on carbon dioxide emission is positively significant. The net inflow of FDI into the region exerts positive significant influence on the growth of carbon emission in the long-run. This may be supported with the argument that FDI introduces heavy polluting intensive production processes to less-developed countries due to less-stringent environmental policies. The implication is that as FDI inflow increases in the sub-region, the growth of pollution density increases in the long run. This is consistent with the positions of Suri and Chapman (1998); Xing and Kolstad (2002); He (2006); and Boqiong and Jianguo (2010). The reported results also show that real per capita income has a significant positive effect on the growth of carbon emission in the selected countries of SSA in the long-run. This implies that as output of goods and services increases in the region, so also is the rate of depletion and deterioration of the environmental quality in the region. This evidence corroborates the earlier studies like Grossman and Krueger (1995), Muhammad *et al.* (2011) and Yu (2012). The result reveals a deteriorating long run environmental quality effect of FDI inflow and economic growth in the SSA countries. It implies that the combination of FDI inflow and real per capita income have long-run positive significant influence on the growth of carbon dioxide emission in the sub-region, leading to low environmental quality in the selected countries of SSA in the long-run.

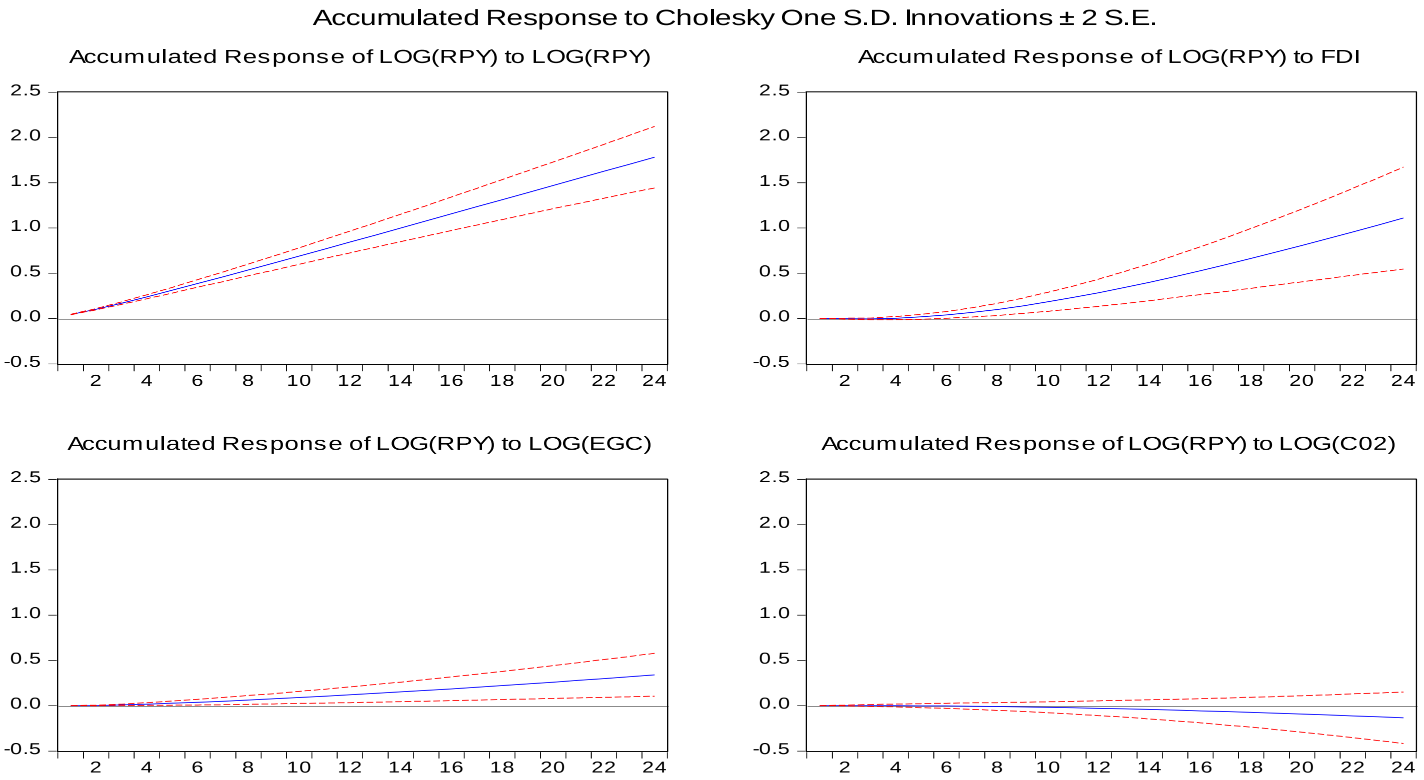
The error correction term explains the swiftness of long-run equilibrium which is required to be negative and less than one which captures the speed of adjustment from short-run distortion in environmental quality to its long-run equilibrium responding to the effectiveness of policies with regards to inflow of FDI, real per capita income and energy consumption. The error correction term results indicated that the net inflow of FDI has the expected sign, but other variables have positive signs. Also, real per capita income and energy consumption have values that are greater than one. The result revealed that the long-run equilibrium in the growth rate of carbon emission is swiftly but not bringing restoration from short-run distortions in the region. This implies that changes in environmental policies in SSA are very slow in restoring equilibrium to short-run distortions in environmental quality of the countries in the sub-region. This reflects the legislative and implementation delay to adoption of effective environmental policies in the sub-region.

The adjustment speed of the net inflow of FDI is fairly moderate. It reflects that the long-run equilibrium of the growth rate of carbon emission responds quickly to the macroeconomic policies that affect the net inflow of FDI, to bring the growth rate of carbon emission into equilibrium quickly within the region. However, the adjustment speed of environmental quality to the real per capita income is shown to be explosive in nature. It reflects that any policy regarding the variable impacts explosively on the long-run equilibrium state of carbon emission in the selected countries of SSA. It implies that the speed of adjustment from short-run distortion in carbon emission to its long-run equilibrium is explosively influenced by the policies determining real per capita income.

4.3.1 Panel Impulse – Response Analysis

The impulse response function traces the response of one endogenous variable to one-standard shock in another variable, which is considered as a dynamic multiplier. The graphs of impulse response functions which show the direction of the effect in line with the signs of the estimates are shown in figure 1 below:


Accumulated Response to Cholesky One S.D. Innovations ± 2 S.E.
Accumulated Response of LOG(C02) to LOG(C02)
Accumulated Response of LOG(C02) to LOG(RPY)
Accumulated Response of LOG(C02) to LOG(EGC)
Accumulated Response of LOG(C02) to FDI


Accumulated Response to Cholesky One S.D. Innovations ± 2 S.E.
Accumulated Response of LOG(RPY) to LOG(RPY)
Accumulated Response of LOG(RPY) to FDI
Accumulated Response of LOG(RPY) to LOG(EGC)
Accumulated Response of LOG(RPY) to LOG(C02)

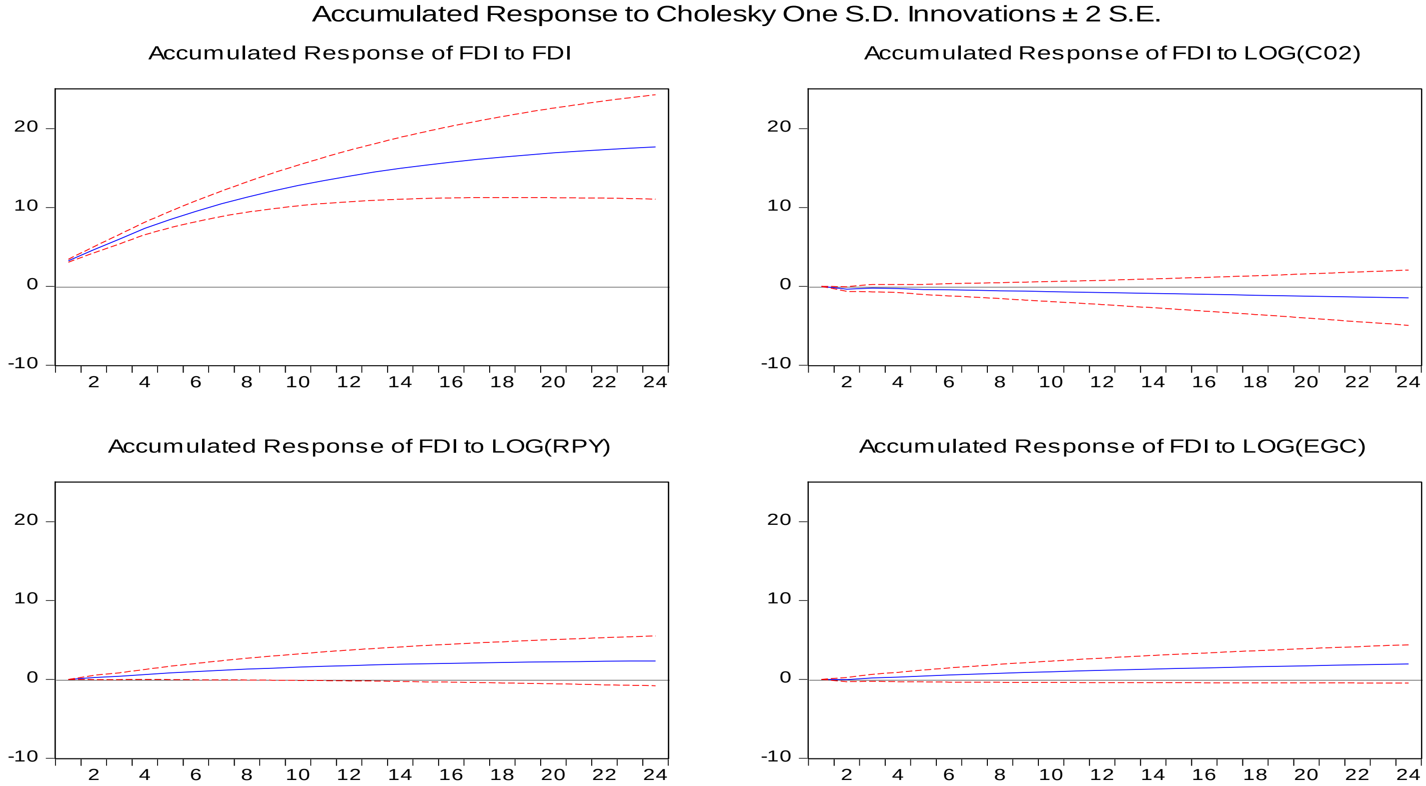


Figure 1: Impulse Response Function among Environmental Quality, FDI and Economic Growth

The first panel considers the response of environmental quality as proxied by carbon dioxide emission to unexpected changes in the other variables of the model. The result presents that a shock to carbon emissions innovation produced a positive effect on actual carbon dioxide emission, a proxy for environmental quality in SSA countries. The trend assumed positive values right from quarter 1 and was sustained till the end of time horizon. Hence, unanticipated change in carbon dioxide emissions was found to increase actual carbon dioxide emissions in the sub – region in the short, medium and long term runs. An innovation to carbon emission could be expansionary in all the time horizons. The result is in line with the findings of Xu and Yi (2005). A shock to real per capita income would also produce positive effects on the actual carbon dioxide emission in the region. Thus, an innovation to real per capita income increases carbon dioxide emission in SSA both in the short, medium and long runs. In the same vein, shocks to foreign direct investment could have positive effects on carbon dioxide emission in the short, medium and long runs. Hence, an innovation to FDI inflow increases carbon dioxide emission in the countries of SSA. The result is in line with Ogunleye, (2009), Kingston, (2011) and Yu, (2012).

From panel 2, a shock to real per capita income *(rpy)* and foreign direct investment would produce a positive effect on actual real per capita income in the short, medium and long runs. It reveals that an innovation to real per capita income and foreign direct investment increases actual real per capita income in the short and long runs. Thus, given all other endogenous factors in the model, real per capita income in SSA could be expansionary in the short, medium and long runs. This result is in line with Xu (2000) and Zang (2008) in China, Yu (2012) in Chile. A shock to carbon emission is also shown to have a crowd out (negative) effect on actual real per capita income in the medium and long runs. An innovation to carbon emission assumed negative values from period 5 through the remaining time horizons. Thus, increase in per capita carbon emission which implies reduction in environmental quality would reduce real per capita income in SSA. A shock to per capita carbon emission would have a contradictory effect on real per capita income in the selected SSA countries both in the medium and long runs. The implication here is that, to increase real per capita income in the region, efforts should be geared towards increasing foreign direct investment and reduction in carbon emission that could come along with it.

The third panel considers the response of foreign direct investment (FDI) to unexpected changes in the other variables of the model. A shock or an innovation to FDI would produce a positive effect on actual inflow of foreign direct investment in SSA. A shock to FDI would have an expansionary effect on the actual inflow of foreign direct investment in the short, medium and long runs. The result is in line with Dinda (2004) and Jing (2008) but contrary to Ogunleye (2009). In the same vein, an unanticipated change in real per capita income is shown to have an expansionary effect on actual inflow of foreign direct investment in SSA. The estimate assumed positive values from period 1 till the end of period 24. Hence, an innovation to real per capita income would have a short, medium and long runs positive effects on the inflow of foreign direct investment in the countries of sub-Saharan Africa. This result is in line with Xu (2000) and Zang (2008) in China, Yu (2011) in Chile. Also, the result reveals that a shock to carbon emission, a proxy for environmental quality, would have an overall negative and contradictory effect on the inflow of FDI in SSA. An innovation to Carbon emission density would have a short run positive effect on the inflow of foreign direct investment in the region. This implies that to increase FDI inflow in the short-run, relaxed environmental regulation that will encourage polluting foreign industries should be embarked upon rather than stringent environmental policy. This supports Pollution Haven Hypothesis. But the trend value of the estimate assumed negative in period 4 and sustained this till the end of the horizon. Hence, the medium and long runs effect of the shocks on carbon emission density is negative on the inflow of FDI into the countries in SSA. An innovation to carbon emission density would have a contradictory effect on the inflow of FDI in the selected countries of SSA both in the medium and long runs.

4.3.2 Variance Decomposition of FDI, Economic Growth and Environmental Quality

To further expose the interactions among foreign direct investment, economic growth and environmental quality in the selected countries of sub-Saharan Africa, the variance decomposition derived from Panel VAR was generated, which shows the explanatory contributions of the shock to innovation of the variables. The standard errors of a variance decomposition are the forecast errors of the variable at the given forecast horizon. Each forecast error is obtained from the variation in the current and future values of the innovations to each endogenous variable in the VAR. The remaining columns give the percentage of the forecast variance due to each innovation. The percentage of the forecast variances in each row under the endogenous variables add up to 100. In particular, the first period decomposition for the first variable in the VAR ordering is completely due to its own innovation, and thus 100 while others are zero each.

Table 5 below shows the result of variance decomposition generated from Panel Vector Autocorrelation estimated for the selected countries of SSA.

Table 5: Results of Forecast Error Panel Variance Decomposition

Variance Decomposition of LOG(C0$_2$)

Period	S.E.	LOG(C02)	LOG(RPY)	LOG(EGC)	FDI
1	0.259591	100.0000	0.000000	0.000000	0.000000
4	0.367859	96.54357	1.260232	1.566220	0.629982
8	0.485640	91.64718	1.953903	2.427640	3.971276
12	0.587368	86.26993	2.407171	3.063573	8.259325
16	0.679521	81.31401	2.728000	3.564795	12.39320
20	0.763875	77.08684	2.959102	3.990682	15.96338
24	0.841419	73.57892	3.129268	4.371157	18.92066

Variance Decomposition of FDI

Period	S.E.	FDI	LOG(C02)	LOG(RPY)	LOG(EGC)
1	3.242764	100.0000	0.000000	0.000000	0.000000
4	4.057216	97.89652	0.968272	0.778700	0.356506
8	4.544709	97.34392	0.905476	1.193863	0.556740
12	4.749010	97.11852	0.885241	1.326889	0.669349
16	4.838011	96.96952	0.908118	1.372197	0.750162
20	4.877299	96.85493	0.945534	1.386394	0.813143
24	4.894893	96.75867	0.987507	1.389652	0.864170

Variance Decomposition of LOG(RPY)

Period	S.E.	LOG(RPY)	FDI	LOG(EGC)	LOG(C02)
1	0.044505	100.0000	0.000000	0.000000	0.000000
4	0.122472	98.66747	0.405014	0.911279	0.016235
8	0.200345	91.72134	6.579049	1.624314	0.075301
12	0.270874	82.45736	15.36258	2.007266	0.172795
16	0.337324	74.57981	22.87165	2.265320	0.283222
20	0.399386	68.56442	28.56104	2.476060	0.398478
24	0.456816	64.05519	32.75782	2.669756	0.517227

The first panel in table 5 depicts the proportion of forecast panel error variance in Carbon emission density explained by innovations of the included endogenous variables. The three variables that appeared important in determining the variations in CO_2 emissions are real per capita income, the net inflow of foreign direct investment and energy consumption. The magnitude of CO_2 reduced from 100 per cent in quarter 1 to 73.6 per cent in quarter 24. The magnitude of GDP increased over time from 0.00 percent in quarter 1 to 1.95 percent in quarter 8 and further increased to 3.13 per cent in quarter 24. The magnitude of EGC increased from 0.00 percent in quarter 1 to 1.57 per cent in quarter 4 before it increased further to 4.37 per cent in period 24. While the magnitude of FDI increased from 0.00 per cent in quarter 1 to 3.97 per cent in quarter 8 and increased further to 18.9 per cent in quarter 24. A shock to CO_2 explained the largest proportion of its own variation in the short run. FDI had greater potential to explain variation in CO_2 in the long run. In other words, the inflow of FDI had greater long run impact on CO_2 than both RPY and EGC. The implication here is that as governments in SSA countries focus on policies that are FDI attractive, environmental qualities continue to deteriorate in the region. Efforts are to be intensified in assessing the qualities of the inflow of FDI to ensure improved environmental condition of the sub-region.

The second panel reveals the proportion of forecast error variance in the inflow of FDI in the selected countries of SSA as explained by shocks to innovations of the considered endogenous variables. The variables that appeared crucial in determine the variations in FDI are FDI and RPY. The magnitude of FDI varied between 100 percent in quarter 1 and 96.76 percent in quarter 24. Innovation to the inflow of FDI has greater potential to increase actual inflow of FDI. The magnitude of RPY increased from 0.00 percent in quarter 1 to 1.39 percent in quarter 24. The magnitude of CO_2 increased insignificantly over time from 0.00 percent in quarter 1 to 0.97 percent in quarter 4 and further increased to 0.99 per cent in quarter 24. Also, the magnitude of EGC increased from 0.00 per cent in quarter 1 to 0.36 per cent in quarter 4 and increased further to 0.86 per cent in quarter 24. Innovations to real per capita has greater potential to increase the inflow of FDI also has greater potential to influence real GDP growth in the selected countries of SSA than those of environmental variables. A shock to FDI explained the largest proportion of its own variation in the short run. Real per capita income had greater potential to explain variation in FDI inflow in the long run.

The third panel depicts the proportion of forecast error variance in real per capita income in the selected countries of SSA as explained by innovation of the considered endogenous variables. The three variables that appeared critical in determining the variations in real per capita income are RPY, FDI and EGC. The magnitude of RPY varied between 100 percent in quarter 1 and 64.1 percent in quarter 24. Innovation to real per capita has greater potential to increase actual real per capita income when compared with other variables. The magnitude of FDI increased from 00.0 percent in quarter 1 to 6.58 percent in quarter 8 and to 32.76 percent in quarter 24. The magnitude of EGC increased from 0.00 percent in quarter 4 to 2.67 percent in quarter 24. While the magnitude of CO_2 increased insignificantly from 0.00 percent in quarter 1 to 0.08 percent in quarter 8 and later to 0.52 percent in quarter 24. The innovation to FDI explained larger proportion of variation in real GDP growth than EGC and CO_2. The implication here is that governments in SSA countries should adopt policies that will attract substantial inflow of FDI as it has long-run impart on the real per capita income.

5. Conclusions and Policy Implications

The paper investigates the dynamic interaction among foreign direct investment, economic growth and environmental quality in thirty-three countries of Sub-Saharan Africa for the period 1980-2013. The variables of interest are shown to be integrated of order one while the panel cointegration test result confirms the existence of a long run equilibrium relationship among these variables. The results of the dynamic interactions among FDI, economic growth and environmental quality as examined under panel vector error correction mechanism, show that each of the variable has positive significant effect on one another both in the short-run and long-run. Impulse response function and variance decomposition were considered which reveal that the included variables explain variations in one another in the sub-region. This confirms the existence of feedback effect among FDI, economic growth and environmental quality in the region of SSA. The interaction among FDI, economic growth and environmental quality followed expected pattern in the selected SSA countries. The dynamic interaction reveals that increase in FDI increased real GDP growth; increase in FDI increased environmental quality but increase in environmental quality did not increase FDI. An increase in environmental quality increased GDP but increase in real GDP did not increase environmental quality. These influences could be attributed to the problem of lax environmental regulations and possibility of capital flights in the region. Non-implementation of environmental regulations continually makes possible entrants of polluting industries which result in increased productivity and environmental degradation. Also, loose economic policies allows repatriation of profits and capital; which inhibit against long term positive impacts of FDI on growth and environmental quality. Sub – Saharan African countries should therefore focus on the effective adoption and implementation of policies that will attract and retain FDI in the region as well as improved environmental quality to ensure consistent economic growth in the sub-region.

From the findings that emerged in this paper, some vital policy implications can be deduced. If governments of Sub – Saharan African countries wish to generate additional economic growth, they should mobilize more foreign capital and also protect their environment. Environmental degradations and pollution from growing productive activities must be put in check through appropriate policy mix. Governments should strike a balance between investment friendly policies and environmental protection policies such that foreign direct investment that will be attracted into the countries in the region will be those that will improve the environmental quality of the region.

Also, governments of Sub – Saharan African countries should intensify efforts to restrict importation of carbon intensive products and check the activities of multi – national companies producing carbon intensive goods in Sub – Saharan African countries. The government should control investment in high energy consumption and high pollution sectors such that pollution emission is minimized. Governments of Sub-Saharan Africa countries should implement sound macroeconomic policies in order to fully consolidate macroeconomic stability. These SSA countries should also move forward more decisively and a more sustained basis to implement environmental policies that will reduce the upsurge of polluting foreign industries in the region.

Governments in Sub-Saharan African countries should harmonise their various macroeconomic policies in such a way that long-run equilibrium will be attained among various macroeconomic variables. The study reveals that the included variables respond independently to macroeconomic policies as they do not follow the same pattern. Policy reforms that are growth – oriented, foreign investors friendly and environmental preserving are necessary in the SSA region.

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