A Co-integration Approach to the Study of Economic Growth and Environmental Impact in Ghana

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Abstract

This paper examines the connection between growth (GDP) and environmental conditions (carbon dioxide emissions) for Ghana from a historical viewpoint. Utilizing rigorous econometric investigation, the outcomes recommend that growth per capita be firmly identified with carbon dioxide emission. The results through the application of the co-integration technique indicate that the growth elasticity of emissions has been increasing after some time. By evaluating the Environmental Kuznets Curve (EKC) for the period 1971-2014, the study approves the existence of a sensible turning point and along these lines; EKC "U" shape was present. The outcome proposes that Ghana could check its carbon dioxide discharges in the last four decades. Along these lines, as hypothesized, the cost of degradation related to GDP grows after some time and the research reveals that economic and human activities have a progressively negative environmental impact on the nation when contrasted with its economic prosperity. The study also reveals that there is a uni-directional causality between growth per capita and carbon emissions. One recommendation outlined in this paper is the continuous utilization of renewable energy by both humans and industries in Ghana.

Keywords: *EKC, CO2 emissions, Pollution, Economic growth, Cointegration.*

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1. Introduction

Ghana is one of the fastest developing emerging economies in sub-Saharan Africa with average annual GDP growth of around 7.9% from 2010 to 2019 (7.9% in 2010 and 6.3% in 2019 - World Bank Data Base, 2019). However, high economic growth is normally linked to expanding energy utilization, which causes an unforeseen impact on energy resources and the environment.

Ghana's energy consumption in 2010 was about 70% lower than its utilization in 2000, decreasing from 325.56 kg per capita to 298.91 kg per capita. CO_2 emissions were higher than the growth of energy utilization, from 0.32 metric tons in 2000 to 0.52 metric tons in 2018. Numerous indicators validate Ghana's high economic growth - industrialization, natural resource extraction, and foreign investment inflows are the most significant indicators.

Growth in all these indicators can be ascribed to Ghana's political, social, and macroeconomic dependability. Additionally, a nation with around 28 million individuals offers an attractive consumer market. Its labor force offers young, skilled, and generally well-educated workers, with labor costs that are competitive with different economies in the region. Its geographic location, rich natural resources, and ideal policies are other factors that pull in investments from numerous nations, which stimulates further economic growth.

There has been a growing worry about global warming primarily emerging from the gigantic scale of worldwide carbon dioxide (CO_2) emissions. Various developed and developing nations have resolved to diminish their domestic CO_2 emissions to a specific level. As a noteworthy developing nation and one of the biggest CO_2 emitters in sub-Saharan Africa, Ghana is presently focusing on decreasing its energy consumption and CO_2 emissions. In the previous decade, Ghana's economic development accelerated by way of ''industrialization and extraction of natural resources''.

The connection between economic growth and environmental conditions has been the subject of extensive research in the course of the last few decades. A few precise examinations suggested that there is an inverse-U-shaped connection between economic activities, generally estimated as far as growth per capita, and the environmental quality (Aldy, 2005). In other words, at the primary phase of economic growth, environmental degradation increases as per capita grows; as per capita growth exceeds a threshold limit, the environmental degradation does not start to decrease. This environmental pattern has been called 'Environmental Kuznets Curve' (EKC) because of the similitude with the connection between the level of inequality and per capita income(Kuznets, 1955).

As per the EKC hypothesis, economic growth will be the solution to environmental problems later on. However, empirical results and conclusions are vague. From one perspective, a few empirical studies have affirmed the presence of an EKC for various estimations of environmental degradation (Brajer et al., 2008, Giles and Mosk, 2003, Panayotou, 2016). Then again, a few researchers avow that there is no evidence supporting the EKC hypothesis and they rather report monotonically expanding or diminishing connection between pollution and per capita income (Douglas and Selden, 1995, Fodha and Zaghdoud, 2010, Tao et al., 2008, Cole, 2004).

The vast majority of these empirical studies use cross-country panel data to evaluate the connection between per capita income and different environmental indicators. Nonetheless, moving from cross-country concentrate to an individual nation's time-series study is another pattern for EKC researchers, since the latter can dispose of the issues related to cross-country data and assess an individual nation. –Lindmark (2002) contends that "historical studies of individual nations offer a favorable position over cross-section approaches in carrying the investigations closer to the dynamic that causes the EKC pattern". Any potential conclusion drawn from these cross-country studies provides a general comprehension of how the variables are comprehensively related and therefore, offers good direction for policy implications.

In line with these contentions, this work endeavors to study the link between CO_2 and GDP growth for the years 1971-2014. The study employed the endogenous properties of carbon dioxide emissions modeling by utilizing an econometric time series method, to be specific, Vector Error Correction Model (VECM). The outcome explores and confirms the conclusions by centering on the long-run relationship between CO_2 emissions and growth. It endeavors to shed some light on the Environmental Kuznets Curve (EKC) in connection with Ghana.

The rest of the paper is organized as follows: Section 2 reviews the theoretical underpinnings and the empirical literature; section 3 presents data and method application; section 4 lays out the empirical results and findings and the final segment concludes the study with policy implication advertisement recommendations.

2. Literature Review

Greenhouse gas (GHG) emissions have strongly expanded, taking over the industrial development in both developed and developing nations. Specifically, carbon dioxide (CO_2) emissions account for over half of GHG emissions, which are likely to be related to climate change (Bank, 2007). The Intergovernmental Panel on Climate Change (2007) shows that GHG emissions have expanded by 1.6% every year, whereas CO_2 emissions, mainly emerge due to the utilization of fossil fuels and have also expanded by 1.9% yearly over the past three decades. Additionally, the Intergovernmental Panel on Climate Change (2007) anticipated that GHG emissions in 2030 will have expanded by 25–90% as compared with the year 2000, and energy-related CO_2 emissions in 2030 will have expanded by 40–110%. Dealing with climate change has become a global concern.

2.1 Growth & Environmental Impact connections

Empirical investigation and examination of the nexus between growth and environmental impact, as specified above, is more often than not followed in the seminal work of Grossman and Krueger (1991) which was propelled by Simon Kuznets literature on economic growth and inequality in 1995. Guided by (Grossman and Krueger, 1991, Panayotou, 2016), different empirical studies have examined the economic growth–environment nexus within the EKC concept. It is worth saying that in later times, the bulk of the empirical studies on the nexus between growth and environmental impact seem to be guided by the EKC hypothesis. The EKC is briefly portrayed in Figure 1 (Panayotou, 2016).

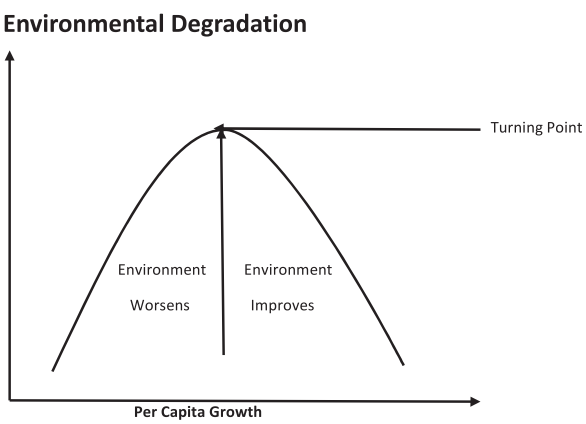

Figure 1: Environmental Kuznets Curve; Source: (Panayotou, 2016).

As presented in Figure 1, environmental degradation increases (i.e. Environment worsens) at lower levels of per capita growth and tends to decrease (i.e. Environment improves) at a higher level of per capita growth. This paper fundamentally centers on the relationship between economic growth and environmental impact in Ghana. Hence, the key variable is economic growth, which is proxied by real GDP (RGDP) per capita. As required by the EKC hypothesis, the squared term of real GDP per capita is included in the set of explanatory variables, in which case the EKC is said to exist if the real GDP per capita is positively marked and real GDP per capita squared incorporates a negative coefficient (Kleemann and Abdulai, 2013, Liu, 2005, Wang et al., 2007, Peng and Bao, 2006)

Analyzing and estimating the EKC hypothesis has increased significantly, as it indicates that growth is a solution for environmental conditions shortly with the help of institutional quality and policy intervention. The EKC hypothesis has been estimated for many environmental degradation indicators, including carbon dioxide emissions. It has been argued that an inverted-U-shaped relationship between economic growth and measured pollution indicators (environmental quality) exists and is thus known as the EKC. Thus, the EKC hypothesis is intended to represent a long-term relationship between environmental impact and economic growth.

As economic development accelerates with the intensification of agriculture and other resource extraction, the rate of resource depletion begins to exceed the rate of resource regeneration, and waste generation increases in quantity and toxicity. At higher levels of development, structural change towards information-intensive industries and services, coupled with increased environmental awareness, enforcement of environmental regulations, better technology, and higher environmental expenditures, results in leveling off and the gradual decline of environmental degradation. As income moves beyond the EKC turning point, it is assumed that the transition to improving environmental quality starts. Thus, it could be a depiction of the natural process of economic development from a clean agrarian economy to a polluting industrial economy, and, finally, to a clean service economy (Ajmi et al., 2015).

The EKC hypothesis summarizes an essentially dynamic process of change; as income of an economy grows over time, emission level grows first, reaches a peak and then starts declining after a threshold level of income has been crossed. However, the statement of the hypothesis makes no explicit reference to time (Stern, 2017). The EKC is a long-term phenomenon; it is a developmental trajectory for a single economy that grows through different stages over time. Empirically, this development trajectory can be observed in cross-country cross-sectional data, which represents the countries with different income groups corresponding to their emission levels (Dogan and Turkekul, 2016). Assuming all countries follow one EKC, and then at any cross-section of time, it should be observed that some countries are poor in shaping the initial stage of the EKC, some are developing countries approaching a peak or start to decline, and others are rich and at the declining stage of the EKC. Thus, under the null hypothesis of EKC and the assumption of invariance of the income–emission relationship, for a given set of cross-country cross-sectional data on income and emission, the emission on income regression line should be an inverted-U-shaped empirical EKC (Naradda Gamage et al., 2017).

Testing the EKC hypothesis becomes increasingly important as it predicts that economic growth is a solution for environmental problems in the future with no policy intervention. The EKC hypothesis has been tested for many indicators of environmental degradation, including deforestation carbon emissions (Lan, 2017, Wen and Dai, 2017). However, empirical evidence for delinking CO_2 emissions and economic growth has not been conclusive compared to other pollutants. While a few investigations found a linear relationship between CO_2 emissions and per capita income (Panayotou, 2016, Yang et al., 2015) others detailed an inverted U-shaped relationship (Apergis and Ozturk, 2015, Singh et al., 2019).

Numerous studies (Dinda, 2004, Hill and Magnani, 2002, Stern, 2004) on EKC utilized either panel or cross-section data for developed and/or developing nations to set up a connection between economic growth and environmental degradation. These studies give a common understanding of how the factors are related; they are incapable of offering many directions on policy implications for each country (Zhou and Ang, 2008). This is because individual countries don't have the same pollution levels as was accepted in panel data analysis –(Stern, 2004, Lindmark, 2002). For example, a study in Malaysia by Vincent (1997) concluded that pollution-income relationship from the cross-country studies (Grossman and Krueger, 1991, Shafik and Bandyopadhyay, 1992, Panayotou, 2016) fail to accurately predict the trends in air and water pollution in Malaysia. In particular, none of the pollution-income relationships estimated for Malaysia have the hypothesized EKC existence, which is inconsistent with the predictions of the cross-country studies. There is a need for a common EKC for all nations to guarantee effective and sustainable development needs, which, in turn, would support carrying out studies on individual country policies.

With the improvement of time series econometric techniques, the focus of research has changed to testing co-integration and causal relationships based on the EKC hypothesis. Steger and Egli (2007) argue that the distinction between short and long-term effects of economic growth on environmental degradation is important; therefore, equations with explicit short and long-term dynamics should be preferred.

Stern et al. (1996) recorded that ''a more fruitful approach to the examination of the relationship between economic growth and environmental impact would be the examination of the historical involvement of individual nations, utilizing econometric and additionally qualitative historical analysis''. At that point, an unused slant of research has shown up in which the EKC hypothesis is tested utilizing time-series data for individual nations. Studies utilizing time-series data for a single nation incorporate those of Roca and Alcántara, (2002). As pointed out by ‒Lindmark (2002), a major advantage of the individual country study is bringing the examination closer to the dynamic. In other words, EKC may be a long-run phenomenon because it portrays the development direction for a single economy that grows through distinctive stages over time(Dinda, 2004).

Recently, Akbostancı et al. (2009) examined the co-integration connection between economic growth and CO_2 emissions in Turkey. In another examination, Fodha and Zaghdoud (2010) investigated the co-integration and the causal connection between economic growth and pollutant emissions (CO_2 and SO_2) given the EKC hypothesis for Tunisia. In an ongoing report, Saboori et al. (2012) assessed the co-integration and causal connection between economic growth and CO_2 emissions based on the EKC hypothesis for 36 high-income nations. They provided evidence on the side of the EKC hypothesis in the instances of Greece, Malta, Oman, Portugal, and the United Kingdom. Another investigation by ‒Esteve and Tamarit (2012) modeled the long-run connection between CO_2 emissions and income for Spain. They finish a non-linear connection between the variables indicating the presence of an EKC.

Some studies included other potential determinants of CO_2 emissions; for example, energy utilization (Ozturk and Acaravci, 2010, Zhou and Ang, 2008, Menyah and Wolde-Rufael, 2010) and foreign trade to test the contamination sanctuary hypothesis (Halicioglu, 2009).

Multivariate studies need to deliver the outcomes in the presence of the EKC. Jalil and Mahmud, (2009), Zhou and Ang, (2008) succeeded in finding an inverted-U shaped curve between economic growth and CO_2 emissions; others have not been able to do so (Halicioglu, 2009, Ozturk and Acaravci, 2010, Menyah and Wolde-Rufael, 2010).

Findings and results of individual countries' studies cannot be compared to outcomes from cross-sectional studies. For instance, the presence of the decoupling phase of the EKC between economic growth and CO_2 emissions in Turkey is not clear during testing when utilizing diverse econometric methodologies with distinctive times and distinctive extra variables. Ozturk and Acaravci, (2010), Akbostancı et al., (2009) conclude that there's no inverted-U shaped relationship between income and CO_2 emissions in Turkey. Some factors are to be taken into consideration when dealing with individual countries' investigation. These factors include the period, variables and method for estimations. Furthermore, prior empirical studies consider testing causality together with testing the co-integration to assess the long-term relationship between environmental degradation and economic growth.

3. Model

The researchers adopted the standard EKC model as used by Piłatowska et al. (2015) to examine the relationship between environmental degradation and economic development in Poland. While the earlier research included only energy consumption, the present research used both energy consumption and trade openness to test the robustness of the outcomes. The earlier research utilized quarterly information between the period 2000-2012 while the present research utilizes yearly information for the period 1971-2014. Including energy consumption in the research is imperative as Ghana has become a lower-middle-income country and its energy consumption level has likewise expanded. The parameter of trade openness is used since Ghana's endeavor to achieve economic development has pulled in more FDI and exchange than most SSA countries. Ghana's steady majority rules system and a conducive business environment have made it the "Gateway" and the goal of FDI in Africa. Worldwide organizations move from developed countries with stricter environmental controls to creating economies where the natural direction is less strict. In addition, the period was chosen when Ghana began producing Oil and Gas resulting in the emanating of carbon emissions. The particular model is given below:

$$CO_2=F\ (RGDP,\ RGDP^2,\ Z)\ldots\ldots\ (1)$$

CO_2 indicates environmental degradation, RGDP represents economic growth, Z captures other factors that add to the contamination of the earth. In this research, CO_2 is proxied by carbon dioxide emissions in metric tons, RGDP is captured in terms of growth per capita and Z adds up to energy consumption and trade openness. An econometric equation based on the EKC hypothesis is developed and represented in equation 2 as follows:

$$CO_2it=a+\ \beta_1 RGDPit+\ \beta_2 RGDP^2it+\ \beta_3 TRADEit+\ \beta_4 ENEit+Uit\ldots\ (2)$$

In the model, the dependent variable is carbon dioxide emissions. The dependent variable and the explanatory variables are portrayed underneath. Environmental degradation, signifying natural degradation, is estimated by yearly carbon dioxide emissions (in metric tons per capita).

As indicated by the hypothesis, it is assumed that carbon dioxide emissions and economic growth have an inverted U-shaped relationship.

3.1 Data

The data set and variables used in this study are spread over the period 1971-2014. Variables used for the investigation are consistent with those of other researchers which include Carbon Dioxide measured in metric tons per capita used by –Aboagye (2017) as the dependent variables, Economic Growth proxies as RGDP measured in current USD as employed by Appiah et al. (2019) with trade openness and energy consumption as control variables. Table 1 gives a summary of the variables with their unit of measurement as well as their sources.

Table 1: Summary of Variables

Variables	Unit of Measurement	Sources
Carbon Dioxide Emissions (CO_2)	Metric tons per capita	WDI
Gross Domestic Product Per Capita (RGDP)	Current USD	WDI
Trade Openness (Trade)	Percentage of GDP	WDI
Energy Consumption (ENE)	KG of oil equivalent per capita	WDI

Source: Authors' Composition

3.2 Methodology

The nature of this study is an exploratory one that tries to find the relationship between economic growth and environmental impact in Ghana.

3.2.1 Unit Root Estimation

The study begins with the estimation of unit root estimations. There are at least two motives why a unit root test has to be performed in this study. First, it was established by Granger et al. (1974) that nonsensical correlations may arise from regressions involving two uncorrelated variables, integrated of order one, denoted as *I* (1). Granger et al. (1974) display that regressions which are uncorrelated often lead to deceptive inference and misleading results.

The second reason for the significance of unit root testing stems from economic theories, making use of equilibrium concepts. Economic equilibria are, as a rule, characterized by stable equilibrium values or growth paths. As it were, small deviations from these equilibrium values are allowed, which are gathered to be expeditiously corrected by market forces. Theories utilizing such equilibrium concepts can be tried by estimation of unit root tests: whereas unit root processes have no propensity to display a stable mean value, but may take after a few unpredictable stochastic paths, stationary variables are characterized by a stable mean (or deterministic trend) around which the observations are fluctuating. In this way, unit root tests may be connected to directly test numerous (macro-) economic hypotheses.

This examination settles on the Augmented Dickey-Fuller (ADF) and the Phillip–Perron (PP) tests, given their small sample superiority. The ADF and the PP tests are based on the following regression:

$$\Delta W_t=\beta_0+\alpha_1 T+\alpha W_{t-1}+\sum_{J=1}^{k} \beta_1 \Delta W_{-1}+\mu_t \text{.........} (3)$$

Where W is the variable that is tested for unit root, T is a linear trend, Δ is the first difference operator and t is time, μ is the Gaussian white noise term and k is chosen to achieve white noise residuals. The study further utilizes the Akaike Information Criterion (AIC) to select the optimal lag.

3.2.2 Co-integration Test Estimation

Co-integration implies economic variables share the same stochastic trend so that they are combined within the long-term. Indeed, in case they deviate from each other within the short-term, they tend to come back to the trend within the long-term. A necessary condition for the co-integration test is that all the variables should be integrated in the same order or contain a deterministic trend (Engle and Granger, 1987). In this manner, these time series within the period are substantial within the co-integration test. Once the variables are co-integrated, the short-term changes can be clarified through the vector error correction model(Engle and Granger, 1987).

The Johansen co-integration estimations are applied in the study to determine the long-term relationship between economic growth and environmental impact. Due to the heterogeneity allowed in the Johansen co-integration estimations, the data for all variables in Equation (1) appears to be co-integrated, implying the presence of a long-run equilibrium relationship among the variables. The Johansen test for co-integration permits more than one co-integrating relationship, not at all like the Engle-Granger method, but this test is subject to asymptotic properties (Giles, 2013, Pesaran et al., 2001). Taking after the co-integration test, the VECM will be utilized to analyze the causality inside the variable utilized. Engle and Granger (1987) recommend a regression equation for co-integration analysis as follows:

$$Y_t=\alpha+\beta_0 X_t+\beta_1 X_{t-1}+\gamma Y_{t-1}+\varepsilon_t$$

Where Y is the dependent variable, α is the intercept, β_0 and β_1 are the coefficients to be estimated; t-1 representsthe lag of the variables.

3.2.3 Vector Error Correction Model Estimation

Taking into consideration the co-integration test, the VECM will be utilized to analyze the long-run effects within the variable used. This study considered the utilization of the Vector Error Correction Model (VECM) because (1) the time series is not stationary in their levels but are in their 1^{st} difference form (2) the variables are co-integrated. The general regression equation for estimating VECM includes the following:

$$\Delta Y_t=\alpha+\sum_{j=1}^{p-1}\beta_0\Delta Y_{t-j}+\sum_{J=1}^{k}\beta_1\Delta X_{\ \ -1}+\alpha\hat{U}_{t-1}+\varepsilon_t$$

Where the residuals ε_t is independent and normally spread with the zero mean and constant variance. The parameter $\hat{U}_{t-1}$ designates the speed of adjustment to the equilibrium level.

3.2.4 Causality Test

The study continued to explore the causality among the variables, especially growth and emissions. Engle and Granger (1987) contend that if two or more series are integrated of order one (1) and are co-integrated, at that point, there might be at slightest one causal link in one direction. The causality test is performed utilizing the standard Engle-Granger causality test procedure over the Toda– Yamamoto test.

The Engle-Granger test recognized causality through the Vector Error Correction (VECM) model by estimating the residuals and comparing it to the deviation from the equilibrium point of vectors. The equations that emerge for the time series Granger causality testing and important to this study are as follows:

$$\Delta Y_t=\alpha_t+\beta_1\sum_{J=1}^{k}\Delta Y_{\ \ -1}+\varphi\sum_{J=1}^{k}\Delta X_{\ \ -1}+ECT+\varepsilon_t$$

Where Δ is the first difference operator, t is time and ECT is the error correction term generated from the short-run co-integration model. The Akaike information criterion is employed to select the optimal lag.

4. Empirical Results

This section talks about the empirical findings and analysis of results. This investigation looks to set up the link between economic growth and environmental impact as well as estimating whether the EKC theory exists in Ghana. The examination will likewise endeavor to decide whether Trade openness influences environmental quality in Ghana including the causality between economic growth factors and environmental impact.

To know the relationships which exist between the dependent variable which is CO_2 emissions and the independent variables, thus RGDP, $RGDP^2$, Trade and Energy, a Pairwise Correlation was estimated.

Table 2: Pairwise Correlation Matrix

Correlation	CO_2	RGDP	$RGDP^2$	TRADE	ENE
CO_2	**1.000000**	0.708603	0.699165	0.829327	-0.274582
RGDP	0.708603	**1.000000**	0.986326	0.929118	-0.541875
$RGDP^2$	0.699165	0.986326	**1.000000**	0.943521	-0.474125
TRADE	0.829327	0.929118	0.943521	**1.000000**	-0.405543
ENE	-0.274582	-0.541875	-0.474125	-0.405543	**1.000000**

Source: Authors' Calculations

The Correlation matrix in Table 2 demonstrates the quality of the relationship between variables. Table 2 demonstrates that a few variables are decidedly related and some are adversely related to one another. The variable Carbon Dioxide (CO_2), that is, the dependent variable, is positively related to all variables aside from Energy Use (ENE). Energy Use is adversely related to RGDP, $RGDP^2$, and TRADE. Trade Openness is emphatically related to all other independent variables aside from Energy Use. It is likewise seen that $RGDP^2$ is additionally profoundly and emphatically corresponded with all factors barring Energy Use.

Table 3: Unit Root Test Results

	ADF LEVEL		PHILLIPSPERRON		ADF 1ST DIFFERENCE		PHILLIPSPERRON1^{st} DIFFERENCE	
Variable	Cons	Cons & Trend	Cons	Cons & Trend	Cons	Cons & Trend	Cons	Cons & Trend
CO_2	3.092018	1.746308	1.973022	1.813781	-5.36388***	-6.01933***	-5.96899***	-6.175019***
RGDP	-0.153286	-4.28965***	-0.15329	-1.272933	-5.34618***	-5.38297***	-5.36839***	-5.321828***
$RGDP^2$	-4.87533***	-6.08177***	-0.65015	-1.719838	-4.18561***	-4.19511***	-5.81437	-5.818319***
TRADE	2.526717	2.006925	1.757054	1.757054	0.75354	-0.084296	-3.17268***	-2.53124
ENE	-1.681037	-2.124319	-1.86067	-1.860668	-6.0877***	-6.01207***	-6.08685***	-6.011058***

Note: *1. Cons = Constant; Cons & Trend = Constant and Linear Trend*
2. ADF and PP are based on Mackinnon's critical values. (***), (**) and (*) indicate statistical significance at 1%, 5% and 10% respectively. Source: Authors' Calculations

To guarantee that the factors are stationary or non-stationary, the Unit Roots test was effected. Furthermore, Unit Root testing maintains a strategic distance from spurious relapses where the model demonstrates promising analytic test outcomes, yet the relapse investigation has no importance (Gujarati and Porter, 2003). There are different methodologies for testing for the existence of a Unit Root, yet this examination employed two of the methodologies that are usually used by analysts; the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests.

Table 3 reports the outcomes of the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test insights at levels and first difference. From the outcomes, we see that every one of the variables accomplished stationarity after first differencing and are, hence, integrated of order 1, that is I(1), suggesting the variables will be investigated utilizing their first difference. This required a co-integration test to set up a long-run relationship among the variables.

Table 4: Co-integration Statistics

	Trace Test		Max-Eigenvalue Test	
No. of Co-integrating Equations	Trace Statistic	5% Critical Value	Max-Eigen Statistic	5% Critical Value
None *	152.8880	69.81889	79.20903	33.87687
At most 1 *	73.67900	47.85613	38.09388	27.58434
At most 2 *	35.58512	29.79707	21.92485	21.13162
At most 3	13.66027	15.49471	8.821911	14.26460
At most 4 *	4.838356	3.841466	4.838356	3.841466

Note: (*) indicates co-integrating equations at the 5% critical level. Source: Authors' Calculations

The idea of co-integration verifiably accepts linearity and symmetry, which implies that the change of the deviations towards the long-run balance is made quickly at every period and increases or declines of the deviations are rectified similarly. The test of co-integration is fundamentally to set up a long-run stable relationship between non-stationary arrangement (Piłatowska et al., 2015). The concept of co-integration is when factors in a theorized relationship ought not to leave from one another over the long haul or on the off-chance that they do wander in the short-run, the dissimilarity ought to decrease over the long haul so the arrangement will be on a similar way. The Johansen co-integration test is favored because it takes into consideration the simple adjustment of sequential correlation. If EKC regression does not cointegrate, the assessments will be spurious. Not very many examinations have revealed any indicative measurements for coordination of the factors or co-integration of the relapses and so it is hazy what we can surmise from the lion's share of EKC hypothesis (Perman and Stern, 2003).

Table 4 presents the Johansen way to deal with the co-integration test and the aftereffects of both the Trace test and Max Eigenvalue demonstrate four co-integrating equations at the 5% significance level. This demonstrates at most four of the variables have a long-term affiliation or balance between one another. Henceforth, the null hypothesis of "no co-integration" is rejected and the alternative hypothesis of "co-integration" is acknowledged at the 5% significance level. The null hypothesis can be rejected if and just if the quantity of co-integrating conditions is more noteworthy than one. For this situation, we acknowledge the two co-integrating conditions, henceforth, the null hypothesis of "no co-integration" can be rejected.

Table 5: VECM Results

Short-run Model					Long-run Model				
Variable	Coefficient	Std. Error	t-Stats	Prob.	Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.05097	0.131983	-0.386186	0.7018	CO_2 (-1)	-0.8129	0.190856	-4.25922	0.0002***
D(RGDP)	0.000235	0.000192	1.224142	0.2296	RGDP(-1)	0.000264	0.000131	2.014209	0.0522*
D($RGDP^2$)	1.05E-07	8.56E-08	-1.229477	0.2276	$RGDP^2$(-1)	-3.22E-07	8.34E-08	-3.86303	0.0005***
D(TRADE)	2.20E-11	1.21E-11	1.819707	0.0779*	TRADE(-1)	5.50E-11	8.25E-12	6.670659	0.0000***
D(ENE)	0.000481	0.00036	1.336599	0.1905	ENE(-1)	0.000482	0.000291	1.655681	0.1073
R-squared	0.694232	Adj R-squared	0.610841	F-stats	8.324999	Prob (F-stats)	0.000002	Durbin-Watson stat	1.568681

Note: (***), (**) and (*) indicate significance at 1%, 5% and 10% respectively. Source: Authors' Calculations

The VECM statistics in Table 5 is to check the long-term relationship between the variables. In light of the outcomes from the estimation of the VECM, the accompanying measurable surmising can be made; Table 5 shows that RGDP, $RGDP^2$, trade openness, and energy use explains about 69.42 percent of variables in carbon dioxide emissions. This is delineated by an R-squared of 0.6942. The probability of the F-measurement is significant at 1% inferring that the model fit is great and the Durbin-Watson measurement of 1.5687 shows that the blunders are not related.

The equilibrium rectification coefficient, CO_2 (-1), has the required negative sign and is profoundly significant at 1%, consequently, the VECM results are substantial and affirm the long-term relationship among CO_2 emissions and RGDP between the period 1971 and 2014. This recommends in case of disequilibrium in the short-term, it will be corrected at an adjustment speed of 81%. The assessed outcomes show that in the short-term, it was revealed that RGDP is emphatically identified with CO_2 emissions while $RGDP^2$ is contrarily generally identified with CO_2 emissions demonstrating a U-Shaped relationship (EKC theory is affirmed). This implies in the short term, introductory development expands CO_2 discharge to a specific income level past which further development diminishes CO_2 emissions.

Over the long haul, RGDP is sure and significant while $RGDP^2$ is negative and significant. This likewise demonstrates a modified U-shape relationship (EKC theory affirmed). This finding affirms that EKC is present. This implies over the long haul, at first RGDP development causes CO_2 emissions to ascend past a defining moment, after which further development in RGDP causes a fall in CO_2 emissions. These discoveries negate Omojolaibi (2010) who neglected to affirm the EKC theory for Ghana, Nigeria and Sierra Leone in a panel data estimation. This fits in with the finding of Shahbaz et al. (2012) who affirmed the EKC theory for Pakistan in the long-term. This affirms the EKC theory is getting to be apparent in creating economies despite prior perspectives.

As indicated by Dasgupta et al. (2002), emerging countries tend to green economy and notwithstanding helping the contamination issue, consequently, the proof of the EKC in emerging countries is not common. Exchanges in the short and long term are decidedly identified with CO_2 emissions with an extraordinary effect and are factually significant both at 10 and 1 percent individually; thus, this research confirms that contamination is present. Energy utilization isn't measurably significant at 1 percent and is decidedly identified with CO_2 emissions; however, the effect is little both in the short and long-term. On the off-chance that energy use increases by 1 percent, CO_2 emissions will diminish by 0.000481 percent in the short-term and 0.000482 over the long haul. The significantly positive effect of energy utilization on CO_2 emissions verify the way that still more is to be done on energy utilization by receiving Renewable Energy Policy being actualized by the government to guarantee that 10 percent of energy age is from sustainable sources which is a decent positive development. Additionally, the Renewable Energy Fund and the new Feed-in-Tariff (FIT) has added to the lessening emissions from energy utilization

Table 6: Pairwise Granger Causality Test

Null Hypothesis:	Obs	F-Statistic	Prob.
GDP does not Granger Cause CO_2	41	6.45375	0.0014
CO_2 does not Granger Cause GDP		4.01943	0.0150
GDP2 does not Granger Cause CO_2	41	12.6535	1.E-05
CO_2 does not Granger Cause GDP2		3.63166	0.0224
TRADE does not Granger Cause CO_2	41	18.8075	2.E-07
CO_2 does not Granger Cause TRADE		0.34916	0.7900
ENE does not Granger Cause CO_2	41	0.22431	0.8788
CO_2 does not Granger Cause ENE		1.05476	0.3811
GDP2 does not Granger Cause GDP	41	3.59429	0.0233
GDP does not Granger Cause GDP2		6.33383	0.0016
TRADE does not Granger Cause GDP	41	5.57831	0.0032
GDP does not Granger Cause TRADE		18.2556	3.E-07
ENE does not Granger Cause GDP	41	5.63242	0.0030
GDP does not Granger Cause ENE		0.26371	0.8510
TRADE does not Granger Cause GDP2	41	16.6411	8.E-07
GDP2 does not Granger Cause TRADE		42.1562	1.E-11
ENE does not Granger Cause GDP2	41	3.68762	0.0212
GDP2 does not Granger Cause ENE		0.11817	0.9488
ENE does not Granger Cause TRADE	41	3.07285	0.0407
TRADE does not Granger Cause ENE		0.29775	0.8268

Source: Authors' Calculations

Granger causality test is broadly used in econometric investigations to set up the heading of causality between or among factors. This test is regularly verified to different tests because it is exceptionally powerful. The Granger causality strategy was proposed by Granger (1969) and in this manner, adjusted by Toda and Yamamoto, (1995). This examination endeavors to build up the course of causality between CO_2, Energy use, GDP and Trade in Ghana.

The Pairwise Granger Causality Test is to check the heading of causality among the factors. The outcomes from the Granger Causality Test demonstrate a uni-directional causality from RGDP to CO_2 and this affirms the presence of EKC; RGDP to exchange transparency; CO_2 to exchange receptiveness which implies powerless natural controls will draw in very polluting firms from abroad; RGDP to energy utilization and at last, from energy utilization to CO_2 emissions which implies Ghana's energy facilities must support the use of sustainable power source to control CO_2 outflows.

5. Conclusion And Policy Implications

The examination explores the relationship between CO_2 emissions, economic growth, energy consumption, and trade openness in Ghana over the period of 1971 to 2014. The outcome recommends that there exists a relationship between the factors. The positive indication of RGDP and negative indication of $RGDP^2$ affirms that the EKC hypothesis is upheld in the country. Energy consumption diminishes CO_2 emissions in both the short and long term. Openness to trade was observed to be noteworthy both in the short and long term situations. The aftereffect of the Granger causality test demonstrates a restricted causal relationship running from GDP and energy consumption to CO_2 emissions; RGDP to energy consumption and trade openness; furthermore, CO_2 emissions to trade openness.

Limitations

Some limiting factors are hindering the study. This study only dealt with Ghana and not all emerging countries on the African Continent. Again, there was a problem of data availability and that led to the limitation of data from 1971-2014. The selection of factors and variables differ from other research studies and became a limitation since there was no data available for such variables. Lack of funds for the purchase of data other than what is available from international organizations was another limiting factor. Finally, some recommendations do not apply to some developing African countries because of different economic situations and climatic conditions.

Applicability & Generalizability

A. Sustainable Development

The huge presence of EKC demonstrates that the country's push to diminish CO_2 emissions and seek sustainable development pathways is very evident. This shows the sensible accomplishment of controlling environmental degradation in Ghana. The ongoing propelling of the Country Climate Change Policy and the Country Environmental Policy in 2014 will harden the country's effort towards sustainable development by diminishing emissions. Notwithstanding, discoveries dependent on total information will be unable to demonstrate the emissions examples of the ten individual areas in the country. It must be accentuated that the usage of this study is fundamental, but not an adequate condition. The requirement for a viable implementation of environmental laws and control is vital at the country as well as the provincial and area levels to keep the "contamination sanctuary theory". Moreover, examination and development exercises on environmental degradation which are vital to achieving sustainable development must be unequivocally sought after in Ghana. In this way, to control CO_2 emissions, there is a need to actualize environmental taxes; for example, green tax. Emerging countries, including India, can adopt the policy of environmental taxing as well as green taxing to help in the mitigation of environmental degradation issues.

b. Advance the utilization of Renewable Energy

The significantly negative effect of energy consumption on CO_2 emissions authenticates the way that the Renewable Energy Policy being executed by the government to guarantee that 10 percent of energy use is from renewable sources is a positive development and must be actualized by both developed and emerging economies. Likewise, the foundation of the Ghana Gas Company to utilize the gas from the oil fields will make gas flaring a relic of times gone by and diminish CO_2 outflow. The gas can likewise be utilized for household and modern purposes and this will diminish emissions further. The evacuation of enormous sponsorships on non-renewable energy sources ought to make economic space for the government to forcefully actualize the renewable energy policy.

Government together with UNEP has grown Low Emissions Development Strategies (LEDS) in different parts to help decrease emissions in Ghana and these strategies must be actualized. To wrap things up, the government must see to the fruitful usage of the Environmental Fiscal Reforms which goes for setting up a Climate Change Fund to be committed to the execution of the Country Climate Change Policy and other environmental exercises.

Data Source

Data for the study were sourced from the World Bank Database. The demand for good and quality statistical data is imperative, and the World Bank database has been utilized by numerous researchers and organizations and announced as credible and authentic. Timely and reliable data are key inputs for great research and results. The World Bank makes a difference in emerging nations to achieve the capability, efficacy, and value of national statistical frameworks.

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