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ARTICLE

Economic Growth, Industrialization, Trade, Electricity Production and Carbon Dioxide Emissions: Evidence from Ghana

Kingsley Appiah [1*] Rhoda Appah[2] Oware Kofi Mintah[3] Benjamin Yeboah[1]

1. AAIS Department, Kumasi Technical University, Box 854, Kumasi,Ghana
2. Atwima Kwanwoma Senior High/Technical School, Box 5104, Adum,Kumasi,Ghana
3. Banking and Finance Department, Kumasi Technical University, Box 854, Kumasi,Ghana

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ABSTRACT

The study scrutinized correlation between electricity production, trade, economic growth, industrialization and carbon dioxide emissions in Ghana. Our study disaggregated trade into export and import to spell out distinctive and individual variable contribution to emissions in Ghana. In an attempt to investigate, the study used time-series data set of World Development Indicators from 1971 to 2014. By means of Autoregressive Distributed Lag (ARDL) cointegrating technique, study established that variables are co-integrated and have long-run equilibrium relationship. Results of long-term effect of explanatory variables on carbon dioxide emissions indicated that 1% each increase of economic growth and industrialization, will cause an increase of emissions by 16.9% and 79% individually whiles each increase of 1% of electricity production, trade exports, trade imports, will cause a decrease in carbon dioxide emissions by 80.3%, 27.7% and 4.1% correspondingly. In the pursuit of carbon emissions' mitigation and achievement of Sustainable Development Goal (SDG) 13, Ghana need to increase electricity production and trade exports.

1. Introduction

Greenhouse gas (GHG) emissions have increased all over the world[1]. GHG emissions consist of pollutants such as Carbon dioxide (CO2), Nitrous oxide (N2O), Methane (CH4), and Fluorinated gases (F-gases). Carbon dioxide emission is considered as the greater determinant of greenhouse gases all over the world, which accounts for more than 60% of the biosphere emissions[2-4]. Ghana economy slowed down from 3.9% in 2015 to 3.3% 2016 based on government implementation of International Monetary Fund (IMF) policy on fiscal and monetary discipline of the Extended Credit Facility. However, Ghana economic growth is projected to increase to 7.1% and 8.0% in 2017 and 2018 respectively [5] provided the government of Ghana can restore its electricity supply. This projected growth in GDP call for high increase of electricity production to meet demand, which is also expected to contribute towards the carbon emission level [6,7]. According to [8] to the United National

**Corresponding Author:*
Kingsley Appiah,
AAIS Department, Kumasi Technical University, Box 854, Kumasi,Ghana;
Tel: +233206437781;
ORCID: http://orcid.org/0000-0002-6931-1996.
Email:kingsleyappiah2004@yahoo.com.

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Framework Convention on Climate Change, Ghana contributes 33.66 million tons (Mt) CO2-equivalent (CO2e) to the universal greenhouse emissions. [9] indicates that energy sector of Ghana contributes 25% to the worldwide anthropogenic CO2 emissions. Even-though Ghana compared to the global average is not considered as one of the high emitters of CO2 in Africa and the World as a whole.[8] further stated that carbon emissions in Ghana have increased significantly over the years and still expected to grow over the coming years.

As Ghana is gearing towards industrialization policy of one district one factory, increase in economic development, electricity availability have become critical to achieve the expected growth needed. Since every sector within the economy, whether social or economic requires electricity, government have to balance its energy portfolio to meet the challenges associated with the industrialization and development [10-13]. Ghana electricity supply coverage as at 2014 stands as 78.3% of the entire country. It is positive in terms of electricity distribution compare to 23.88% in 1990 [14]. This means that in order to meet the 2030 agenda for sustainable development, electricity will play a critical role[15,16]. Another key issue of concern is the trade impact on carbon emission. Ghana for some time now has attracted considerable trade inflow and outflow which in turn increase economic activities across the country. According to World Integrated Trade Solution (2016), Ghana is ranked at 64th position as the largest export economy to the world. In the year 2016, Ghana export value was around a tune of $10.5Billion whiles import value $11Billion with a negative trade balance of $508Million. However, little work has been done [17-19] on the impact of trade both import and export on Ghana's emissions level.

The study aimed to investigate the causal relationship between the variables in Ghana and also to find each variable contribution to emissions in Ghana. It is common to link industrialization, economic growth, electricity production and trade to CO2 emissions. The importance of this paper could be seen from the contributions it makes to the existing body of knowledge by disaggregating trade into exports and imports of goods and services to explicate the distinct and to find out how trade exports, and imports of goods and services contribute to carbon dioxide emissions level in Ghana individually. The study will serve as an important policy guide to government in Ghana.

The study categorized the remaining discussions into sections with literature review in section 2, materials and methods in section 3, results and discussion in section 4, whiles the conclusion is in section 5.

2. Literature Review

A lot of studies have shown positive relationship between industrialization, electricity consumption, economic growth, trade and carbon emissions[20-22] whiles[23] empirical study also found negative relationship between the variables. Some of the scholars' findings indicated one-way directional association from energy depletion to economic evolution[22,24]. Others also found the causality running from energy consumption to CO2[25] whiles[21,26,27]; found the causality running from economic growth to CO2. Subsequent studies found bidirectional nexus between the variables [20,28].

Study of 31 developing countries applied dynamic panel threshold framework[29]. Study findings attest to other researchers' findings that economic growth contributes to CO2 emissions in these countries. However, economic growth has a negative effect on CO2 emissions, particularly when the growth is low but economic growth, however, exhibits a positive effect when growth is high. To buttress findings of study results affirmed the view that economic growth causes carbon dioxide emissions and affects positively the energy intensity of a country whiles examining both direct and indirect effect of urban growth on energy concentration in China[29][30]. Similarly, also investigated the causal dynamics of emissions, energy use and output in six emerging states in Africa [31]. Results inveterate presence of long-run effect of carbon emissions and economic growth on energy consumption in Ghana whiles economic growth is seen as the positive driving force of energy consumption of countries such as South Africa, Ghana and Kenya. Unidirectional causality was found to run from economic growth to carbon dioxide emissions of countries like Nigeria, Senegal and Egypt. Study using ridge regression to find empirical relationship between carbon dioxide emissions, imports, exports and population in China for the period 1985 to 2006[32]. The study found an increasing trend in carbon emissions caused by exports. The study brought into being that import increase causes carbon emissions reduction in China.

Conducted a study to find association between carbon stock, electricity production, and consumption. Expending ARDL model and data set from 1971 to 2012, the study found bidirectional causality from electricity production, hydroelectric sources to carbon emissions and vice-versa[33]. This means that electricity production and consumption increases carbon dioxide emissions in Ghana. Also explored the correlation among energy, economic development, emissions, trade and urban growth in newly industrialized countries. The results of the study

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showed that there is no long-term relationship between the variables. Nevertheless, the results of the study show a one-way relationship between economic development and global trade to CO2 emissions in short-run[23].

In the same disposition, unidirectional relationship was found running from economic growth to energy consumption, from trade openness to economic growth, from urbanization to economic growth, and from trade openness to urbanization in the short run. Investigated how the relationship exists in Turkey for the period 1960-2005[34]. The study was conducted using bounds' cointegrating test. The findings are that carbon emissions, energy consumption and foreign trade have effects on income in Turkey in the long run. Therefore, to ensure economic development, Turkey should strive to reduce the carbon emissions through the adoption of macroeconomic policies.

2.1 Economic Growth

Economic growth and ecological pollution nexus has been researched globally by so many researchers[30,31,35-41]. Some of the findings showed that economic growth causes environmental pollution[3, 29-31, 42, 43] whiles' others hold the contrary view [44-48].

2.2 Industrialization

It assumed that as the industrial activity level of country increases, all things been equal, it also increases energy usage[49]. Study by [50] to find the effect of industrialization and urbanization on CO2 in 20 African countries from 1980 to 2013. Findings indicates that the effects of the two variables are classified as direct and indirect. The study found both industrialization and urbanization to have a direct negative effect to the environment of the countries. However, the study also found both variables to have an indirect positive effect on environment. That is, at a certain point in time industrialization will reduce the environmental degradation by swarming over the direct effect.

2.3 Trade

Some of the recent studies found a trade relationship with carbon dioxide emissions level to be positive[36,51] whiles' others found the relationship to be negative[23,52]. In contrast, other findings are inconclusive[19,53]. Most of the studies aggregate exports and import as trade and failed to find their individual essential contribution to emissions[23, 52, 54-56]. Different words are used by other researchers to mean the same as trade such as foreign trade or trade openness.

2.4 Electricity Production

Electricity is considered as one of the key determinants of any country's economic growth and development. Electricity plays a crucial and indispensable role in our life in terms of cooking, heating, lighting and powering of industries' machines. For sometimes now Ghana electricity supply has been unreliable. The three primary electricity generation mixes in Ghana are hydro, thermal and renewable. The first two, thermal and hydro as at 2016 contributed 56.94% and 42.84% individually to Ghana's electricity generation synthesis whiles renewables contributed 0.22%[57]. Electricity production in Ghana over the period from 2006 to 2014 has increased by 53.77%, from 8,430 GWh to 12, 963GWh relatively [58]. As at 2016, the total electricity produced for distribution was around 13,700 GWh as against 11,692 in 2015 and 13,071 GWh in 2014; i.e. 2,008 GWh (about 17%) more than in 2015 and 629 GWh (about 5%) more than in 2014 [57].

2.5 Carbon Dioxide Emissions

Lately, carbon dioxide emissions and its relation to other variables have conventionally received greater attention from researchers[59-61]. Diverse findings were found that support the view of the relationship of CO2 with other variables to be positive [62-66], negative [67] and neutral [68-70].

3. Materials and Methods

Even-though [33] attempted to explore the causal relationship between carbon dioxide emission and electricity production using ARDL regression analysis in Ghana. This study added industrialization and trade to the vital variable sets which are utilized in most topical research work [33, 71, 72]. The study further disaggregate trade into imports and exports in the nexus. The whole idea is meant to find their contribution independently to carbon emissions in Ghana. To test for the correlation between economic growth, industrialization, electricity production, trade import, trade export and carbon dioxide emissions in Ghana, the study applied econometric model framework. Our study followed recent studies methodology [33, 73, 74] used by other researchers in both developed and developing countries such as Ghana. All variables were recorded based on their natural logarithm. This phenomenon is common in econometric analysis.

3.1 Data and Variable Definitions

In attempt to investigate the nexus between economic

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growth, industrialization, power production, trade imports, trade exports and carbon dioxide emissions in Ghana, our study made use of time series data set from 1971 to 2014. Using Autoregressive Distributed Lag (ARDL) model, data set was obtained from World Development Indicators. The variables used as explanatory variables include; GDP-Gross Domestic Product per capita (current US $) as proxy of economic growth, IND-Industry, value added (% of GDP) as proxy of Industrialization, IMP-Import of goods and services (% of GDP), XP-Export of goods and services (% of GDP), EP-Electricity production from hydroelectric sources (% of total) and CO2-Carbon dioxide emissions (metric tons per capita) as the dependent variable.

3.2 Econometric Methods

Empirical model ARDL developed by [75] is extensively used by many researchers due to its desirable features. One of the key features of ARDL use is its ability to accommodate both stationary and non-stationary data set series in a regression which hitherto was impossible in other approaches such as Johansen's modeling technique. The adoption of ARDL is because the method is applicable whether or not the variables are integrated in the same order. That means that, analysis of data set can be performed whether some of the variables under study are integrated at level I (0), first order, I (1) or even fractionally integrated. Additionally, ARDL offers unbiased long-run approximations and useable statistical values (i.e. t-statistics) when some of the predictors to the model are endogenous. ARDL allows distinctive lag-lengths to be used in the same model with unlike variables. ARDL techniques help in derivation of the dynamic unrestricted error correction model which intends also to help in determination of both the short and long term without losing any relevant data. To determine the long-run nexus between electricity production, trade, economic growth, industrialization and carbon dioxide in Ghana, the study used unrestricted error correction OLS estimation technique.

4. Results and Discussion

4.1 Model Specification

To determine the long-run elasticities estimate between carbon emissions, economic progress, industrialization, trade imports, trade exports and electricity production in Ghana can be expressed in a linear function as:

$$CO2_t = f(Ep_t, IMP_t, XP_t, GDP_t, IND_t) \tag{1}$$

That is, EP, IMP, XP, GDP and IND represent electricity production, trade imports, trade exports, economic growth and industrialization respectively. To reduce multiplicative relationship to an addictive one requires the need to take the natural-log of the variables in equation (1). The transformation to the variable in

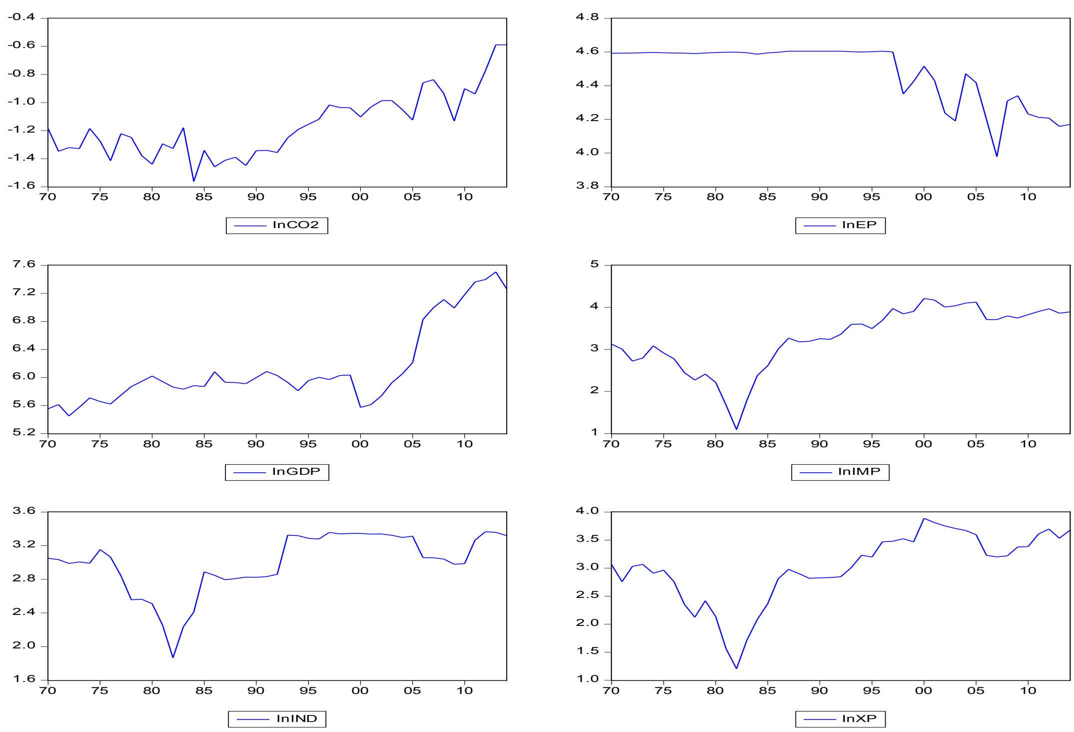

Figure 1: Trend analysis of the variables

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natural logarithms is meant to ensure that study variables have a more stable data variance, and therefore, our Log-log linear relationship between carbon dioxide emission, electricity production, trade imports, trade exports, economic growth and industrialization is expressed as follows:

$$\log CO2_t = \alpha + \varpi_p \log EP_t + \lambda_j \log IMP_t + \sigma_k \log XP_t + \psi_L \log GDP_t + \nu_q \log IND_t + \varepsilon_t \qquad (2)$$

where α is the constant, $\varpi_p, \lambda_j, \sigma_k, \psi_L and \nu_q$ are the coefficient of EP, IMP, XP, GDP and IND respectively. ε_t also represent the white noise of the analysis. The trend of the study variables are shown in Figure 1.

4.2 Descriptive Analysis

The kurtosis results in Table 1 exhibited leptokurtic distribution for all variables. Skewness test results clearly shows that CO2 and GDP display a positive skewness (long-right tail) while EC, EP, IMP, XP and IND exhibited a negative skewness (long-left tail). Table 1 result of Jarque-Bera (JB) test statistic shows that the null concept that the series are normally distributed cannot be accepted at 5% p-value for all the variables except CO2. Even-though most of the variables data were found not to be normally distributed, we went ahead to conduct the analysis since the test is not sensitive to normality.

Table 1: Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max	Skewness	Kurtosis	JB test	Prob.
CO2	-1.166	0.227	-1.562	-0.589	0.681	3.027	3.478	0.176
EP	4.480	0.175	3.978	4.605	-1.151	3.010	9.935	0.007
IMP	3.265	0.740	1.093	4.208	-0.908	3.292	6.348	0.042
XP	3.005	0.624	1.205	3.888	-0.931	3.495	6.965	0.031
GDP	6.123	0.567	5.449	7.504	1.284	3.317	12.571	0.002
IND	2.997	0.353	1.867	3.365	-1.145	4.071	11.990	0.003

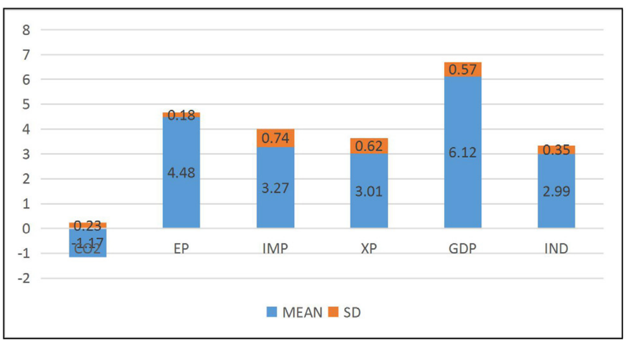

Figure 2: Diagram showing Descriptive Analysis

Figure 2 explains the means and the amount of variability (i.e. standard deviation) of the analysis. Analysis in Figure 2 shows that economic growth (GDP) gave the mean of 6.12, which then becomes the critical variable in Ghana. Notwithstanding that, our standard deviation depicted in Figure 2 exposed imports of goods and services as most volatile variable with highest deviation of 0.74 followed by exports of goods and services of 0.62 in Ghana.

4.3 Unit Root Test

Analysis in Table 2 provides the fundamental test prior to determination of cointegrating relationship between the variables. To test for stationary and non-stationary of the variables, the study applied Augmented Dickey-Fuller (ADF), Philips and Perron (PP) unit root test to execute this task. Nonetheless, time-series data such as ours most of the time produces non-stationary results at the level. The analysis outcomes confirmed this assumption in Table 2, which shows that datasets are non-stationary at the level for both ADF and PP. However, data become stationary at first difference. Hence, accept null proposition at level that unit root exist for entire variables. Hence, the study rejected the null theory of the presence of unit root of the variables in their first difference.

Table 2: Unit root test

	ADF Level	ADF 1st Diff.	PP Level	PP 1st Diff.
		Intercept		
CO2	0.12(0.96)	-9.65(0.00)	-0.54(0.87)	-10.79(0.00)
EP	0.94(0.99)	-8.49(0.00)	-1.61(0.47)	-8.99(0.00)
IMP	-1.41(0.57)	-5.37(0.00)	-0.96(0.76)	-4.62(0.00)
XP	-1.42(0.56)	-5.07(0.00)	-1.23(0.65)	-5.04(0.00)
GDP	-0.06(0.95)	-5.25(0.00)	-0.06(0.95)	-5.25(0.00)
IND	-1.41(0.57)	-5.41(0.00)	-1.63(0.46)	-5.30(0.00)
		Intercept and Trend		
CO2	-3.29(0.08)	-9.87(0.00)	-3.15(0.11)	-27.42(0.00)
EP	-1.27(0.88)	-9.03(0.00)	-3.63(0.14)	-10.38(0.00)
IMP	-2.63(0.27)	-5.29(0.00)	-2.09(0.54)	-4.56(0.00)
XP	-2.29(0.43)	-5.02(0.00)	-2.26(0.45)	-4.98(0.00)
GDP	-1.23(0.89)	-5.27(0.00)	-1.36(0.86)	-5.23(0.00)
IND	-2.06(0.55)	-5.37(0.00)	-2.25(0.45)	-5.26(0.00)

Note: Augmented Dickey-Fuller (ADF), Philips and Perron (PP)

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4.4 ARDL Co-integration analysis

To test for cointegrating among the variables, the study used ARDL bounds testing. The use of ARDL cointegrating technique is to test for the long –run equilibrium relationship between the variables under discussions. Akaike information criterion (AIC) was used to select the optimal model for the bounds' test based on its superior power for data, which is small compared to another lag length criterion [76]. Results provided by AIC is considered as efficient and consistent compared to another criterion. The optimal model provided ARDL (1, 0, 2, 1, 2, 0) as depicted in Figure 3. The study then applied ARDL bounds test to determine both lower (I0) and upper bounds (I1) in order to compare it to the F-statistic value. Drawing from Table 3, results indicates that our F-statistic value of 3.90 is greater than the critical values of the upper bound at 10%, and 5%. This means that cointegration exists among the variables at 10% and 5%. Therefore, the null hypothesis of no cointegration between CO2, EP, IMP, XP, GDP and IND cannot be accepted. However, at 2.5% and 1%, our test is inconclusive since our F-statistic falls between the lower and upper bounds.

Table 3: Bounds test for co-integrating relation

T-Statistic	Value	K
F-Statistic	3.90	5
Bounds Critical Value		
Significance	I0 Bound	I1 Bound
10%	2.26	3.35
5%	2.62	3.79
2.5%	2.96	4.18
1%	3.41	4.68

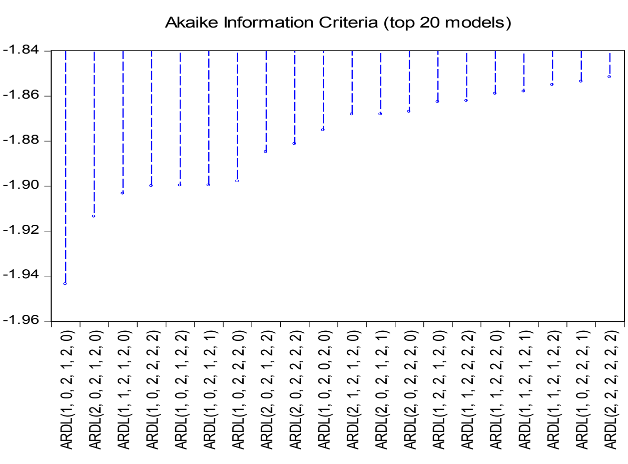

Figure 3: ARDL model selection using akaike information criterion

4.5 Vector Error Correction Model

Having satisfied the pre-condition of ARDL bounds test approach, the study then followed the work of [77] to estimate the Vector Error Correction Model (VECM) is expressed as:

$$(1-L)\begin{bmatrix} CO2_t \\ EP_t \\ IMP_t \\ XP_t \\ GDP_t \\ IND_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \\ \alpha_6 \end{bmatrix} + \sum_{i=1}^{m}(1-L)\begin{bmatrix} \beta_{11i}\beta_{12i}\beta_{13i}\beta_{14i} \\ \beta_{21i}\beta_{22i}\beta_{23i}\beta_{24i} \\ \beta_{31i}\beta_{32i}\beta_{33i}\beta_{34i} \\ \beta_{41i}\beta_{42i}\beta_{43i}\beta_{44i} \\ \beta_{51i}\beta_{52i}\beta_{53i}\beta_{54i} \\ \beta_{61i}\beta_{62i}\beta_{63i}\beta_{64i} \end{bmatrix} \mathrm{X} \begin{bmatrix} CO2_{t-i} \\ EP_{t-i} \\ IMP_{t-i} \\ XP_{t-i} \\ GDP_{t-i} \\ IND_{t-i} \end{bmatrix} + \begin{bmatrix} \gamma_1 \\ \gamma_2 \\ \gamma_3 \\ \gamma_4 \\ \gamma_5 \\ \gamma_6 \end{bmatrix} [ECT_t - 1] + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{bmatrix}$$

Where (1-L) epitomizes the change operator, m is the lags, ECT_{t-1} denote the error correction term meant for long-run integration. The α 's, β's and γ's represents the parameters whiles ε_t 's are the white noises. With regards to Table 4, which presents the results of the short and long run estimates of the ARDL model shows the speed of adjustment [ECT (-1)= -0.873, P=0.000] which makes the residue from our model to be negative but significant at 5% level. Hence, giving the model speed of adjustment towards equilibrium at 87.3%. This gives a clear indication of long-run equilibrium relationship from EP, IMP, XP, GDP and IND to CO2. The long-run equilibrium relationship was undertaken using F-tests based on null hypothesis of no cointegration between carbon dioxide emissions, electricity production, import of goods and services, export of goods and services, economic growth and industrialization $[H_0 : \varpi_p = \lambda_j = \sigma_k = \psi_L = v_q = 0]$, with an alternative hypothesis of cointegration between CO2, EP, IMP, XP, GDP and IND $[H_1 : \varpi_p \neq \lambda_j \neq \sigma_k \neq \psi_L = v_q \neq 0]$. Wald test technique discoveries in Table 4 shows a rejection of the null hypothesis that, independent variables (i.e. EP, IMP, XP, GDP and IND) combined cannot influence CO2 increase in the short-term. Subsequent findings also revealed that individual predictor with the exception of GDP can influence CO2 in the short-run. However, in the long run, EP, XP, GDP and IND were found to be significant and therefore, can influence the dependent variable.

4.6 Diagnostic Test

The next analysis is to perform key diagnostic test such as the stability test, heteroskedaticity test, serial correlation test, normality test and Ramsey RESET test. The performance of these tests is to ensure that the model is robust. To authenticate our VECM model robustness, the study performed further test to ensure that there is no serial correlation in the residuals, residuals are not heteroscedastic, residuals are normally distributed and no

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Table 4: Results of the short and long run estimates of the ARDL Model (Dependent Variable: CO2)

Variable	Coefficient	Standard Error	t-Statistic	Prob.
ECT(-1)	-0.873	0.140	-6.235	0.000*
		Long-run Coefficients		
EP	-0.803	0.170	-4.727	0.000*
IMP	-0.041	0.087	-0.473	0.639
XP	-0.277	0.135	-2.056	0.048*
GDP	0.169	0.045	3.738	0.001*
IND	0.790	0.167	4.722	0.000*
C	0.019	1.022	0.019	0.985
		Diagnostic test		
Heteroskedaticity:				
F-Statistics	1.040	Prob. F(2,38) 0.363	2.128	0.345
Serial Correlation:				
F-Statistics	0.527	Prob. F(2,29) 0.596	1..509	0.470
Ramsey RESET test:				
F-Statistics	0.222	(1,30) 0.640	0.472	0.640
Jarque-Bera test	0.534			0.766
		Short-run equilibrium relationship		
Wald test	F-Statistics	Prob.	Chi-square	Prob.
EP	9.428	0.001*	18.856	0.000*
IMP	3.974	0.033*	7.948	0.019*
XP	4.223	0.027*	8.445	0.015*
GDP	1.247	0.306	2.495	0.287
IND	3.785	0.038*	7.569	0.023*
Jointly	4.005	0.003*	40.055	0.000*

*Note: *denotes significance level at 5%.*

variable is omitted from the analysis. Outcomes in Table 4 indicates a P-value of 0.77 > 0.05 of the residual analysis, and therefore, we accept the null hypothesis that residuals are normally distributed. Our test results provided undoubted view of non-existence of heteroscedastic effect in the model. Hence, accept the null assumption of no heteroscedastic effect in the model as shown by the P-value 0.35 > 0.05. The study serial correlation using Breuch-Godfrey Serial Correlation Lagrange Multiplier test also accepted the null proposition that there is no serial correlation and that our P-Value>0.05. Stability test of the model was performed through the use of CUSUM

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and CUSUM of squares. Our results in Figure 4 and Figure 5 shows that in both CUSUM and CUSUM of squares lines fall within the 5% significance level which confirmed the VAR stability conditions of the model. The Ramsey RESET test on the other hand, also projected that no variable is omitted in the model and therefore, the null hypothesis of no omitted variables in the model cannot be rejected at 5% significance level and that no misspecifications in the model.

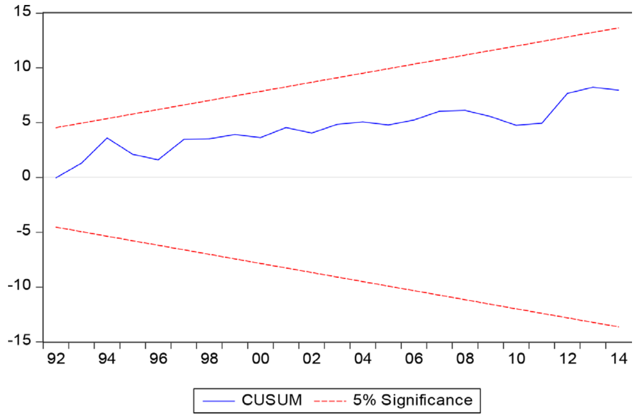

Figure 4: CUSUM

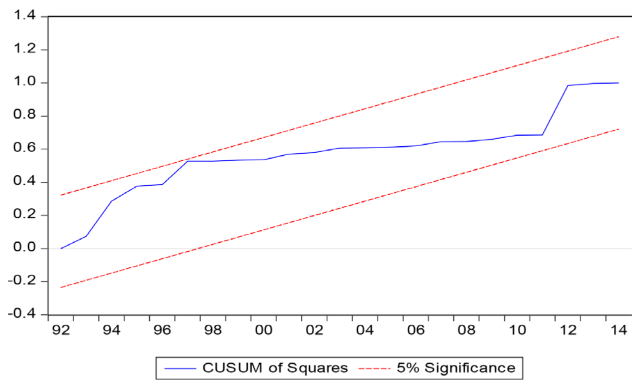

Figure 5: CUSUM of squared

4.7 Granger-Causality

The next stage involved the test of causality to define the cause-effect relationship between the variables. Results in Table 4 indicated that there is long-term relationship between the variables at 5% significance level. However, the application of ARDL to determine the long-run relationship failed to address the issue of cause and effect for the variable among themselves, particularly with regards to CO2. It is against this background that our study went further to employ Granger-causation based on VECM to assess direction of causality among variables. Granger causality test in Table 5 shows that the null hypothesis that INCO2 does not Granger cause INEP does not hold at 5% significance level. Therefore, reject the hypothesis and accept the alternative that INCO2 causes INEP in Ghana. The test also revealed that imports and exports are the two volatile variables in Ghana as disclosed in our descriptive analysis diagram (i.e. Figure 2), which shows that both causes carbon dioxide emissions (CO2) and industrialization in Ghana. Table 5 disclosed unidirectional causality runs from INCO2→INEP, INIMP→INCO2, INXP→INCO2, INIMP→ININD and INXP→ININD at 5% significance level. The use of (→) denotes the direction of causality.

Table 5: Granger causality relationship

Null Hypothesis	Obs.	F-Statistic	Prob.
INEP does not Granger Cause INCO2	43	1.48442	0.2395
INCO2 does not Granger Cause INEP		3.90700	0.0286**
INGDP does not Granger Cause INCO2	43	1.24672	0.2989
INCO2 does not Granger Cause INGDP		0.15422	0.8576
INIMP does not Granger Cause INCO2	43	3.81590	0.0309**
INCO2 does not Granger Cause INIMP		1.21570	0.3078
ININD does not Granger Cause INCO2	43	2.31635	0.1124
INCO2 does not Granger Cause ININD		1.39498	0.2602
INXP does not Granger Cause INCO2	43	3.24637	0.0499**
INCO2 does not Granger Cause INXP		2.47634	0.0975
INGDP does not Granger Cause INEP	43	1.13192	0.3330
INEP does not Granger Cause INGDP		1.21046	0.3093
INIMP does not Granger Cause INEP	43	3.00490	0.0614
INEP does not Granger Cause INIMP		0.86311	0.4300
ININD does not Granger Cause INEP	43	1.32791	0.2770
INEP does not Granger Cause ININD		0.41707	0.6620
INXP does not Granger Cause INEP	43	2.73846	0.0774
INEP does not Granger Cause INXP		0.86542	0.4290
INIMP does not Granger Cause INGDP	43	0.67698	0.5142
INGDP does not Granger Cause INIMP		0.33938	0.7143
ININD does not Granger Cause INGDP	43	0.27036	0.7646
INGDP does not Granger Cause ININD		0.34656	0.7093
INXP does not Granger Cause INGDP	43	0.88922	0.4194
INGDP does not Granger Cause INXP		0.69573	0.5050
ININD does not Granger Cause INIMP	43	0.40427	0.6703
INIMP does not Granger Cause ININD		5.07777	0.0111**
INXP does not Granger Cause INIMP	43	3.07134	0.0580
INIMP does not Granger Cause INXP		2.32720	0.1113
INXP does not Granger Cause ININD	43	4.70297	0.0150**
ININD does not Granger Cause INXP		0.23137	0.7946

***denotes rejection of the null hypothesis @ 5% significance level.*

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4.8 Generalized Impulse Response

The performance of Granger-Causality is to test the direction of causality among series but has its own drawbacks of not probing into how variables, particularly the dependent variable (CO2) will respond to random innovations in other variables. Application of generalized impulse-response analysis is meant to overcome the inherent problem that comes after the current period and also to prevent orthogonal problems associated with out of sample Granger-causality tests. That is, the Generalized Impulse Response analysis is meant to find the responsiveness of the outcome variable (i.e. CO2) in the VAR when there is a random innovation of the individual predictor. Figures 6 shows a skyward increase or decrease of the predictor's one standard deviation shock to CO2 emissions in Ghana from time period 5 to 10. From period 1 to 5, all the variables showed a rising trend shock to CO2. However, response of INCO2 to INEP, INXP and ININD shows a gradual decline from period 5 to 10. Nonetheless, same cannot be said about the response of INCO2 to INGDP and INIMP, that is, constant upward trends are envisaged. Results of the Generalized Impulse Response function encapsulated the response of INCO2 to an innovation of the explanatory variables. Findings in Figure 6 showed that within 10-period horizon, the response of INCO2 to INEP and; INCO2 to ININD is that one standard deviation shock given to INEP and ININD caused a decrease in INCO2 is insignificant. In contrast, the response of INCO2 to INXP over the period is significant but decreasing steadily. Moreover, response of INCO2 to INGDP and INCO2 to INIMP shows a sign of continual trend and significance within the 10-period horizon. The findings from Generalized Impulse Response Function indicated that when one dispersion shot is imputed in economic advancement (GDP), and trade imports caused a constant increase in carbon dioxide emissions in Ghana. However, when one standard deviation is introduced into exports, it causes an increase in carbon emissions with a downward trend. Contrary, when a standard deviation plan is calculated in industrialization and electricity production leads to a decrease in carbon dioxide emissions in Ghana by a constant trend over time.

5.Conclusions

Empirical investigation was performed to find the causal relationship between electricity production, economic growth and CO2 by including industrialization and splitting trade into imports and exports of goods and ser-

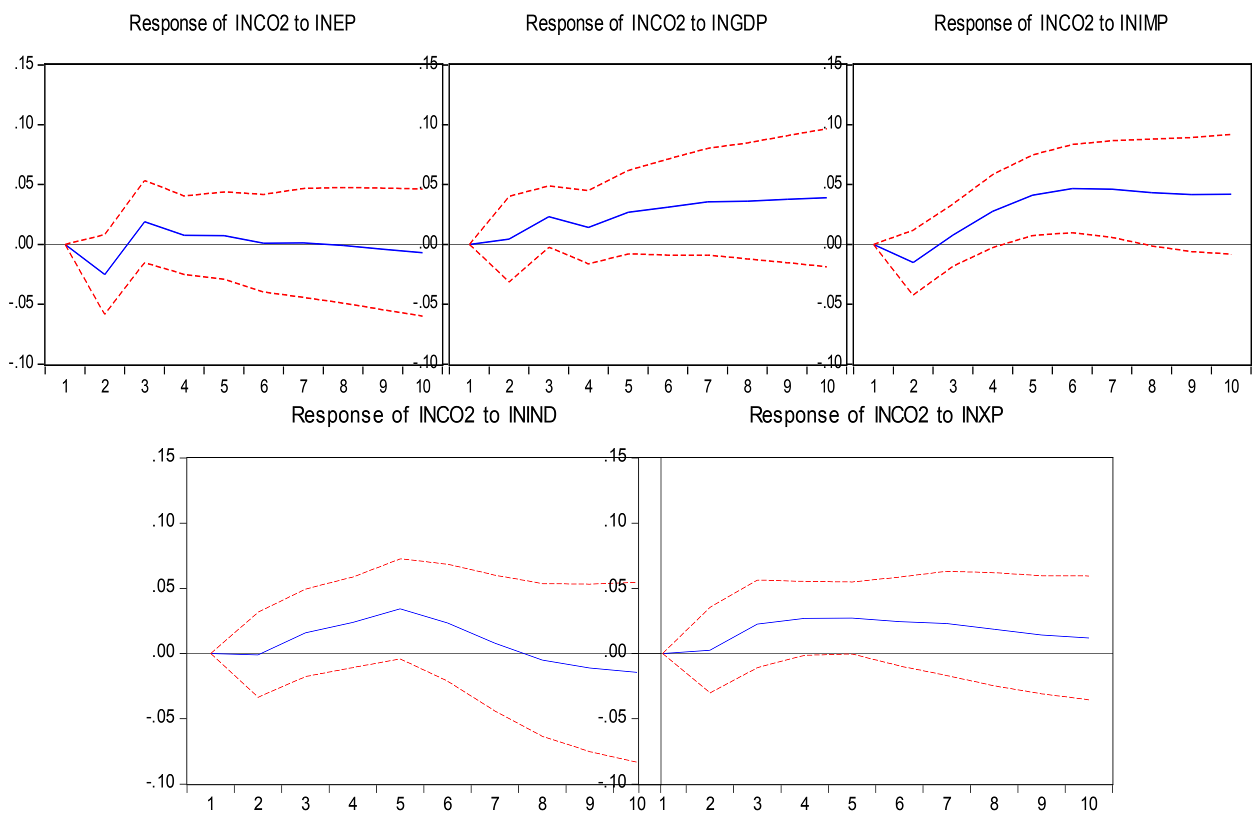

Figure 6: Response of carbon dioxide to other variables

vices to find the potential determinants of CO2 emissions in Ghana. The study with regards to Ghana perspective has become relevant and significant as Ghana is gearing towards industrialization of one district one factory policy, increase in economic growth, increase in trade and development, electricity availability has become critical to achieve the expected growth and development needed. The realization of the outlined policies is assumed to increase the emissions level across the country. Therefore, the need to find the potential marginal effects or contribution to the emissions levels for policy guidance in Ghana. Using Autoregressive Distributed Lag (ARDL) model and time series data set for the period 1970 to 2014 from World Development Indicators. Subsequent to the determination of cointegrating relationship, the study employed Augmented Dickey-Fuller (ADF) and Philips and Perron (PP) test to check the stationary and non-stationary of the data set. Findings indicate that variables are stationary at their first difference. Evidence from Bounds test shows long-run cointegrating exist between the dependent variable and explanatory variables. Results of bounds test further explains the joint effect of the predictors to the dependent variable (CO2) at constant will increase CO2 emissions by 1.9% in Ghana. Wald test shows that, all the variables are significant at 5% in the short-term except for GDP.

Nonetheless, the long-term effect on the variables on CO2 emissions indicated that GDP and IND increase of 1% each will cause an increase of CO2 emissions in Ghana by 16.9% and 79% individually. Nevertheless, one-percent change in the magnitude of electricity production, trade exports and trade import causes a decrease in proportionate change of CO2 emissions by 80.3%, 27.7% and 4.1% correspondingly. The study findings made it clear that increase in electricity production, trade exports and trade imports in Ghana is a plus in reducing CO2 emissions. The reverse is the case with an increase in GDP, and IND. Granger causality test found uni-directional causality runs from CO2→EP, IMP→CO2, XP→CO2, IMP→IND and XP→IND. On this score one can deduce that Ghana economy is trade-led economy. Therefore, implementation of good policy to improve trade (i.e. both import and export) taking into account the environmental effect will help Ghana to achieve its industrial economy policy. The findings from Generalized Impulse Response Function indicated that one standard deviation shot is charged in economic growth (GDP), and trade imports (IMP) caused a constant increase in carbon dioxide (CO2) emissions in Ghana. However, one standard deviation shot is imputed in trade exports (XP) causes an increase in carbon dioxide (CO2) emissions at a declining trend. Contrary, when one standard deviation shot is imputed in industrialization (IND), and electricity production (EP) causes a decrease in carbon dioxide (CO2) emissions in Ghana at constant trend over the time period.

Our results support the findings of [33] that uni-directional causality runs from carbon dioxide emissions to electricity production. Similarly, fallouts of the study support the findings of [23, 32] that uni-directional causality runs from both imports and exports to carbon dioxide emissions. However, our findings support [78] study but hold a contrary view to the findings of [32] to the effect of exports in the long term. In the pursuit of carbon emissions' mitigation and achievement of Sustainable Development Goal (SDG) 13, Ghana need to increase electricity production and trade exports.

Conflict of Interest : No conflict of interest to be declared by all authors of the study.

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