DETERMINANTS CARBON DIOXIDE (CO_2) EMISSIONS ON THE GAMBIA ECONOMY: AN EMPIRICAL STUDY

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ABSTRACT

This study investigates the socio-economic variables that are responsible for the production of carbon dioxide emissions in The Gambia. This study, in particular, looked at the relationship between CO2 emissions and gross domestic product per capita, population density and trade balance. The study employed the Vector Error Correction Model to determine the dynamic relationship between CO2 emissions and the variables such as GDP per capita, population density and trade balance. The findings of our study revealed that there is a long run relationship between CO2 emissions and the variables. In other words, GDP per capita and population density positively impacts on the growth of CO2 emissions in The Gambia, while the influence of trade balance was negatively associated. Therefore, the institutions responsible for the reduction of carbon emissions in The Gambia, should be more proactive in the implementation of the Kyoto Protocol in switching to less polluting energy mix.

Keywords: The Gambia, CO2 emissions, GDP per capita, relationship, population density, trade balance

Introduction

The activities of human beings and their utilisation of the ecosystem put more pressure on the bio-diversity of the world, causing problems such as global warming and climate change, ozone layer depletion, health risks, destruction of plants and ugliness to our natural beauty. The humans are just one species among millions of living organisms that inhabit the planet, Earth. We share our environment with many other living things, and so far humans have been able to exploit natural resources in the ecosystem more than any other living creatures on earth in providing inputs for their production processes1. These productions of goods and services are the results to the rising levels of the Greenhouse Gases (GHGs), such as carbon dioxide, methane, and nitrous oxide among other chemicals in the atmosphere. This study therefore looks at the relationship between one of the most important human induced GHGs, the carbon dioxide, on The Gambian economy. Anthropogenic CO2 is an element with one molecule of carbon and two molecules of oxygen that comes mainly from emissions of combustion of fossil fuels – coals, natural gas, oil, and land use change, which is mostly driven by deforestation2.

However, CO2 is naturally present in the atmosphere as part of the earth's carbon cycle (the natural circulation of carbon among the atmosphere, oceans, soil, plants and animals). The effects of human ecological foot print on the ecosystem is alarming and causes variations in the atmospheric condition of the planet, earth, that sometimes causes havocs like floods, hurricanes, tsunami, heat waves and droughts. The largest human induced CO2 emission is Fossil fuel consumption that has been, in large part, attributed to economic growth through activities of electricity generation, transportation and industrial needs. The Gambia assumes the same global trends in emissions as the energy sector being the main emitter of CO2 accounts for 66 percent (218 Gg CO2), while the Land Use Change and Forestry (LUCF) being the other key source accounting for 34 percent of emissions (110 Gg CO2) (Government of The Gambia, 2012).

The possible impacts The Gambia is steadily experiencing due to variations in the climate change are on the level of crop production, forestry, fisheries, rangelands and livestock attached with other related global problems such as economic and social vulnerability to climate change. This has indebted The Gambia to be a signatory to various protocols and treaties on climate change. Notwithstanding, The Gambia has tasked itself to reduce GHG emission from key sectors of the economy by 44.4 percent by 2025 and 45.4 percent by 2030 with both domestic and international support through the United Nations Framework Convention on Climate Change (UNFCCC), and making significant policy changes in implementing the Kyoto Protocol to enhance a vital reduction in the CO2 emission (Gambia, 2007; Government of The Gambia, 2012).

In a bid to provide the much needed viable information on the theme for possible future actions by the policy implementers in The Gambia, the study looks into the relationship between CO_2 emission Metric tons per capita and the explanatory variables GDP per capita, trade balance percentage of GDP and population density – people per sq. km of land area. Therefore, the study concentrates on whether CO_2 emissions Metric tons per capita are linked to GDP per capita, trade balance percentage of GDP and population density – people per sq. km of land area in The Gambia, as suggested in other empirical literatures in other countries.

[1] UNEP-United Nations Environment Programme (1987) – Policy guidelines for the control of environmental pollution in the urban areas of developing countries.
[2] M. Katz, WHO Geneva, 1969 – The Measurements of Air Pollutants, Guide to the Selection of Methods.

This study is designed to test the hypotheses linking the economic activities of The Gambia and the trends in the carbon dioxide emissions in the atmosphere. This unique features and vulnerability of the country to economic and climatic problems make this work a special one since there is no study that had been done on the Gambia or any country with similar related characteristics of a small population cum least developing country.

The VECM analysis was conducted on the data obtained to investigate the relationship between the emission of CO_2, economic development, population density and trade balance impacts. The findings are expectedly supposed to be quite clear in explaining the interrelationship between economic development, population density, trade balance and carbon dioxide emission rates.

Empirical Literature

The majority of literature on the determinants of the CO_2 emissions focused on the relationship between economic development and carbon dioxide emission with an extended consideration whether the EKC relationship holds. Accordingly, (Holtz-eakin and Selden, 1995) and (Roberts and Grimes, 1997), in their works, the pioneering claims that the relationship of the shape of several emissions (air pollutants) and Gross Domestic Product (GDP) assumes an inverted-U curve kindles an interesting empirical issue which prompted many works such as, Grossman and Krueger (1991), Solow (1991), Beckerman (1992), Nordhaus (1992), Shah and Larsen (1992), Shafik and Bandyopadhyay (1992), Hettige, Lucas & Wheeler (1992), Selden & Song (1995) and Stern, Common & Barbier (1996). However, Gossman and Krueger (1995) claimed that the turning point of the EKC for several pollutants have a tendency to occur before countries reach a GDP of US$ 8,000 per capita. This claim put many countries particularly the developing countries like The Gambia out of suitability for the EKC relationship. (Arrow et al., 1995) the attainment of a high standard of living is a pre-condition for following a good and admirable environmental amenities, since people will prefer to spend more income on the legislations and institutions of environmental quality.

Studies on African countries such as KEHO (2015) an econometric analysis on the long run determinants of CO_2 emissions in Ivory Coast, Western Africa, supports the notion of environmental Kuznets curve. The results further outlined that per capita income, share of industrial GDP and trade openness derives the CO_2 emissions, while the effects of trade openness on CO_2 emissions relies on the structure of the economy and rises as the country engages industrialisation. Also, the literature outlined the complementary relation of trade openness and industrialisation in worsening environmental quality in Ivory Coast. Also, a study by Boopen and Vinesh (2011) on the relationship between CO_2 emissions and economic growth in Mauritania, suggested that the carbon dioxide emissions trajectory is diligently associated with the GDP time path, but the estimates of the data in the study failed to establish the inverted U-shaped EKC. However, the analysis concludes that economic and human activities are having increasingly negative environmental effects than the desired economic prosperity of the Mauritanian economy.

In a related study on the factors causing CO_2 emissions in Southern Africa and what actions to be taken, by the Centre for Environmental Economics and Policy in Africa concludes that the main driving force behind CO_2 emissions is income per capita. But, the study states that, there is no evidence of the linkage between the variables to depict an existence of the EKC among the six countries covered by the study. However, the study resolved to suggesting policies to curb the environmental problems by establishing robust measures in reducing carbon emissions by switching to less polluting energy mix.

The econometric analysis of factors influencing trade openness, economic growth and urbanisation as reasons for greenhouse gas emission in Africa. A study by Onoja et al., (2014) confirmed the existence of the EKC hypothesis in the continent. The findings further revealed that the GDP growth rate and trade openness serve as the major long-run and short-run determinants of greenhouse gas emissions. Hence, recommending African countries to take immediate positive policy measures that will enhance green economy on the continent.

The Environmental Kuznets Curve relationship was tested and explored for a single industrialised open economy, Austria, but the results of the findings outlined that a cubic (i.e. N-shaped) relationship between the GDP and the CO_2 emissions was found to fit the data most appropriately than the EKC for the period under the study (1960-1999). The results also stated that a structural break is identified in the mid-seventies due to the oil price shock. In this research, the authors used the variables of CO_2 as the dependant variable and GDP per capita as the independent variable, with two additional significant variables of import shares and tertiary (service) sector of total production (GDP) shares. Friedl and Getzner (2003).

The empirical evidence of a study in 69 countries using a constructed dynamic three income level of high income, middle income, and low income global panel data modelled to look into the determinants of carbon dioxide emissions. The findings revealed that trade openness, per capita GDP, and energy consumption that is used as a proxy to the per capita electric power consumption and per capita total primary energy consumption, showed positive effects on the CO_2 emissions. While urbanisation has a negative impact on the CO_2 emissions in all the three income panels. For the global panel, only the GDP per capita and per capita total primary energy consumption were found to be statistically significant determinants of the CO_2 emission. Urbanisation, trade openness, and per capita electric power consumption had negative effects on the CO_2 emissions.

Sharma (2011), Tucker's (1995) analysis of the relationship between CO_2 emissions and per capita income in 137 countries in 21 years span concluded that there was a positive relationship between them, and that as per capita incomes accelerate across countries, emissions increased. He posited that, an increased demand in environmental protection is as a result of higher income levels. Therefore, any successful implementation of emission reduction proposals must assure that incomes will not be adversely affected, particularly the less developed countries (LCDs).

De Bruyn, Van Den Bergh, and Opschoor (1998) conducted a research of economic growth and emissions in line with the EKC. They argued that the estimation of the panel data of countries is determined by the inverted-U relationship between income and emissions. They based their arguments on the insights from intensity of use analysis in resource economics, which they used an alternate growth model to estimate for the emissions of the three pollutants (CO_2, NOx, and SO_2) in four different countries (Netherlands, UK, USA and Western Germany). They finally concluded that the time patterns of the above emissions link positively with economic growth, and that reduction in emission could have been attained as a result of structural and technological changes in the economy.

Shi's (2003) empirical assessment and forecasting of the population's impact on carbon dioxide emissions on a data for 93 countries from the period of 1075 to 1996, varied with the earlier researchers like Dietz and Rosa (1997), whose assumptions are that there is a unitary elasticity of emissions with respect to population change, i.e. that a 1% rise in population results the same percentage increase in emissions. Shi stated that in the last two decades population change is greater than proportionally associated with growth in the CO_2 emissions, and that the developing countries suffer more than the developed countries in terms of the impacts. This pronouncement suggests that the impact of population growth is obvious and that it is one of the deriving factors behind the rapid increase in the global CO_2 emissions.

Jayadevappa and Chhatre (2000) examined the direct and indirect effects of environmental quality or problems on international trade. The authors performed a wide-ranging review on their relationships, and suggested that there exist certain linkages between trade and environment. Also, they stressed the variance in agreement and the scanty knowledge on the nature of interactions that exist between international trade theories, development process and the environmental quality. However, they stressed the relative difference in environmental measures in various countries and that the roles of the governments are crucial in establishing environmental policies and regulations that should be in line with dynamic trade theories.

The studies by Holtz-eakin and Selden (1995) on the relationship between the CO_2 emissions and economic growth, stated that estimations derived from the global panel data they obtained exposed that, as GDP per capita increases there will be a marginal propensity to emit carbon dioxide. Also, its growth will continue at 1.8 percent annually for the foreseeable future, which is not functional to the average growth in emissions. Instead, output and population will grow most rapidly in lower-income countries with high marginal propensity to emit due to the distributional effect of policies for emission reduction.

Al-Tuwaijri, Christensen and Hughes (2004) argued that a good environmental performance has an important bearing with a sound economic performance and also measureable environmental disclosures of specific pollution methods and incidences. In using the simultaneous approach to determine the joint relationship between the functions of environmental disclosure, environmental performance and economic performance argued that the previous literature's mixed results was due to the approaches by the different managements and strategies in addressing these various corporate responsibilities.

In conclusion, from the literature we realised that most of the studies were done on developed economies while there are few specific studies that use socio-economic variables like CO_2, GDP per capita, population density and trade balance on developing country. Therefore, we want to fill the research gap of revealing the relationship of the CO_2 and the variables such as GDP per capita, population density and trade balance.

Methodology

Taking into consideration the fact that the relationship of CO2 emissions and the variables of GDP per capita, population density and trade balance, we therefore present the data and methodology used in the analysis. The relationship between CO2 emissions and economic growth is examined using an annual time series data for The Gambia obtained from the World Bank and the United Nations Conference on Trade and Development. The tests of 'unit root test' and co-integration are discussed as to identify the stationarity and the long-run relationship of the variables respectively. Also, the Granger causality test was employed based on the Vector Error Correction Model (VECM) to show the relationship and association between the variables but not specifically implying causation. Finally, the variance decomposition and impulse function are employed to examine the long run dynamic and perturbation of the explanatory variables will have on the dependent variable. This empirical study used the secondary annual time series data for the period 1966 to 2011. They were obtained from various sources notably, from the World Bank, World Development Indicators (WDI) and the United Nation Conference on Trade and Development (UNCTAD).

Empirical Results

Unit Root Test

The test of the unit root employed on the variables verified whether the model is stationary at level or what differencing. The presence of the unit root depicts that the time series variables are non-stationary at level. Hence, using the Augmented Dickey Fuller (ADF) test and the Phillips Peron's (PP) test bring the variables to stationary. The initial employment of all the variables to their logarithm form helps in the elimination of the trend at a level, first and second differencing. For the lag length for each of the variables, we selected the lag length three based on the Akaike's information criterion (AIC).

The results from the Table 1.1 below indicates that the null hypothesis is accepted at 5 percent level of significance for the presence of the unit root in each of the variables, which further outlined that all the variables were non-stationary at the level but it becomes stationary at first differencing at 1 percent level. This suggests that the variables are stationary at the first difference

indicating that they are all integrated in order one I(1). Meeting the properties of stationary by all the variables at first differencing, gives room for the employment of the co-integration test to determine the dynamic relations between the variables.

Table 1. 1: Results of Unit Root Test

Test on Level					
	ADF		PP		
Variable	No Trend	Trend	No Trend	Trend	
LnCO2	-2.3520	-1.6932	-2.4180	-1.9103	
LnGDP	-2.5952	-2.2535	-2.6016	-2.8105	
LnGDP2	-2.5866	-2.2534	-2.6030	-2.8022	
LnPD	-2.5513	-2.4599	-2.6505	-2.8728	
LnTB	-1.7607	-2.2767	-1.8310	-1.5371	
Test on First difference					
	ADF		PP		
Variables	No Trend	Trend	No Trend	Trend	Stationary
LnCO2	-6.0180*	-3.9101*	-5.9980*	-6.1647*	I(1)
LnGDP	-6.6016*	-6.8105*	-6.7276*	-6.5815*	I(1)
LnGDP2	-6.6030*	-6.8022*	-6.6296*	-6.5228*	I(1)
LnPD	-5.2505*	-5.3728*	-5.4255*	-5.5278*	I(1)
LnTB	-7.6310*	-7.5371*	-6.9398*	-7.4567*	I(1)

Note: The values in the table are t-statistics, * indicate significance at 1 % level

Co-integration Test

The findings show that all the variables were non-stationary at level. We conducted the co-integration test via the Johansen's test of co-integration to validate the existence of a long-run relationship between the variables of the study: The $lnCO_2$, lnGDP, lnPD, and lnTB. The outcome of the test as indicated in table 1.2 rejects the null hypothesis of no co-integration among the variables. Both the trace and maximum Eigen statistics were adjusted for degree of freedom. It is disclosed that the variables are co-integrated at 1 percent, and 5 percent levels of significance, showing three Co-integrating vectors.

Table 1. 2: Johansen-Julius Co-Integration Tests results

Test Statistics					
Null	Eigen Value	Trace		Maximum Eigen Value	
Hypothesis		Statistics	5% CV	Statistics	5% CV
r = 0	0.7318	132.7047*	69.8188	55.2779*	33.8768
r ≤ 1	0.6124	77.4266*	47.8561	39.8106	27.5843
r ≤ 2	0.4687	37.6160*	29.7970	26.5622	21.1316
r ≤3	0.2208	11.0538	15.4947	10.4808	14.2646
r ≤4	0.01355	0.5729	3.8414	0.57298	3.8414

Notes: * denotes rejection of the null hypothesis of no co-integration at 1% significance level. CV = Critical Value. The Trace and Maximum Eigen statistics values have been adjusted for degree of freedom as stated by (Reinsel-Ahn, 1992).

Since the model contains co-integration relationship among the variables, then we can proceed to the VECM and the long-run equation, which is:

$lnCO2 = -12.9809 + 1.4459GDPt\text{-}1 + 1.8475GDP^2t\text{-}1 + 2.6487PDt\text{-}1 - 3.6684TBt\text{-}1$

S.E	(0.84053)	(0.76174)	(0.913742)	(0.431785)
T-stats	[8.18052]	[8.16979]	[7.33603]	[8.49475]

Table 1.2 shows that the Johansen test statistic was adjusted for a degree of freedom to obtain the co-integrating equations as suggested by Reinsel-Ahn (1992). Also, shows the results that both the maximum Eigen and traced values exhibit the long-run relationship between the variables. In other words both Trace test and Max-Eigen test are statistically significant to reject the null hypothesis of r = 0 at 1 percent significance level. But was adjusted for degree of freedom, therefore indicating a long-run co-integration relationship between the CO_2 and the independent variables. This infers that the variables of the GDP, GDP², PD and TB will influence the CO_2 emissions growth rate in The Gambia in the long-run. Similarly, any variation between these variables in the short-run will be fine-tuned or adjusted in the long-run through the forces of the government environmental policies and regulations that holds the variables together.

As outlined in the long-run equation, the coefficients of all the variables indicate the expected signs of the theory that they are positively related to the CO_2 emissions growth except for the trade balance having a negative relationship. Explicitly, a 1 percent increase in the GDP per capita will generate a rise of 1.4 percent of the CO_2 emissions, while the population density's 1 percent increase will lead to 2.6 percent of emissions. For the GDP² which is affected by the effects of the EKC shows a positive relationship in the long-run equation with a 1 percent increase in the GDP² yielding a 1.8 percent of emissions. Finally, the trade balance always shows deficits due to imports and exports imbalance. This has a negative impact of 3.7 percent in the CO_2 emissions growth at every 1 percent increase in trade balance. The indications of the autonomous variable suggests that if all the variables are held at constant the CO_2 emissions growth will reduce by 12 percent.

The findings portray that the GDP per capita, population density and trade balance have a vital role in the CO_2 emissions growth in The Gambia considering the positive and significant relationship between both the GDP and PD variables, and the negative effects of the difference on imports and exports composing the trade balance. However, since The Gambia is a least developing country relying hugely on imports from developed countries to supplement the needs of the citizenry, a deficit trade balance signifies more exports that greatly reduces The Gambia's industrial activities. Hence, this reduction in the industrial activities will subsequently reduce the CO_2 emissions rate. The finding of our paper is consistence with the findings suggested by (KEHO, 2015) that the main drivers of the CO_2 emissions are the industrial GDP share and trade balance, while the effect of trade balance on the emissions depends on the structure of the economy.

Furthermore, our findings is associated with the recent studies by (Bash, 2015) which suggest that income per capita is the main driving factor of the CO_2 emissions in Southern African countries, and that the short term fluctuations in per capita does not determine the emission growth.

Granger Causality Test

The Granger causality test was employed to determine the short-run dynamic relationship among the variables of the model since they are integrated in order one as well as co-integrated. We gauged the direction of the causation among the selected variables by engaging the VAR system based on the VECM methodology. From Table 1.3, the short-run effects were exhibited, where the GDP per capita and GDP square cause variations in the CO_2 emissions in The Gambia at least 5 percent significance level, while the population density was at 5 percent significance level. The population density causes variation in the GDP per capita at 5 percent significance level and this could be due to the rapid growth in the population which is a component of the per capita GDP calculations. Also, the trade balance causes variations in the GDP at 1 percent level of significance which can be associated to the performance level in terms of economic growth. The causation of the GDP towards the variation in the TB was at 5 percent level of significance. This was due to effective policy directives towards imports and exports of the country.

The finding as shown in Table 1.3 indicates a unidirectional causality running from GDP per capita to CO_2 emissions, GDP square to CO_2 emissions, and from trade balance to CO_2 emissions. On the other hand, there is bidirectional causality between CO_2 emissions and GDP per capita. The findings on the bidirectional causal relationship between GDP and CO_2 emissions is in line with the findings of Ferda (2008) who suggested in her findings the bidirectional relationships. This finding was re-examined by Dinda and Coondoo (2006) by employing more modern time series econometric techniques to determine the relationship between income and carbon emissions. They concluded in their observation that there was an evidence of a bidirectional causality in the African and Asian countries.

Table 1. 3: The Results of Granger Causality Tests

Independent variables

χ^2-statistics of lagged 1st differenced term [p-value]

Dependent Variables	ΔLCO2	ΔLGDP	ΔLGDP2	ΔLPD	ΔLTB
ΔLCO2	- -	8.7805*	8.6913*	2.259	11.8999**
		-0.0324	-0.0337	-0.5204	-0.0095
ΔLGDP	10.2228**	- -	4.2504	9.7292**	12.1537*
	-0.0475		-0.2357	-0.0304	-0.0069
ΔLGDP2	6.7033	4.2298	- -	1.7892	0.9228
	-0.0824	-0.2377		-0.6173	-0.8199
ΔLPD	7.4317	0.7413	0.7763	- -	0.9208
	-0.0593	-0.8634	-0.8551		-0.8204
ΔLTB	5.6921	6.6327	1.2485	0.58528	- -
	-0.1276	-0.0846	-0.7414	-0.8998	

Notes: * and ** denotes rejection of the null hypothesis of no co-integration at 1% and 5% of significance level and the P values in parentheses. We reject the null hypothesis when $P < 0.05$

Figure 1.1 below shows the interpretation of the above Table 1.3. It is showing the direction of causation among the variables. Population density is seen to be positively and significantly related to the CO_2 emissions in the analysis of this study, without causal relationship. But there exists a unidirectional causality from the population density to GDP per capita that is associated to the findings of many economists such as Birdsall and Wheeler (1993), Lee and Roland-Holst (1997), Jones and Rodolfo (1995), who all stressed that trade is not the root cause of environmental degradation. They pointed out that trade improves environment through composition effect or abatement effect, such as rise in income with tight environmental regulations thereby creating pollution reduction innovations.

Figure 1.1: Variables Causation Channels

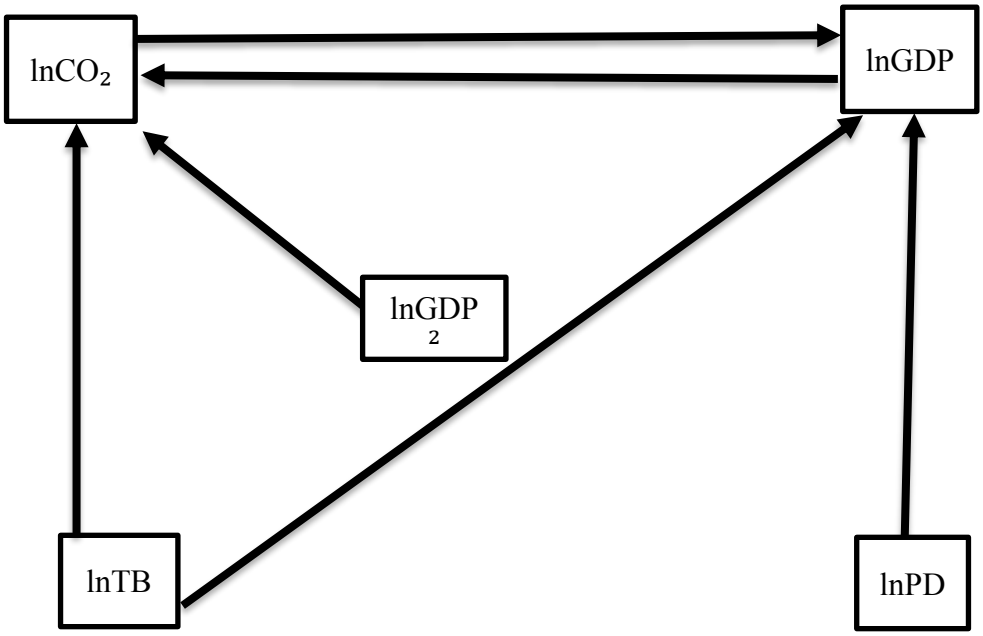


Table 1. 4: VECM Results (Dependent Variable: ΔlnCO2)

Coefficient Estimates of							
Lags	ECT*	ΔlnCO2	ΔlnGDP	ΔlnGDP2	ΔlnPD	ΔlnTB	C
1	-0.0545	0.25526	20.2244	-1.7372	0.3662	0.1199	0.0354
	(0.0121)	(0.17203)	(54.8951)	(4.5764)	(1.4036)	(0.1426)	(0.0241)
2		0.02935	109.426	-9.0615	2.2008	-0.0008	
		(0.16179)	(42.8060)	(3.5697)	(2.1413)	(0.1263)	
3		0.39643	41.2255	-3.4399	1.9934	-0.0742	
		(0.14444)	(35.8986)	(2.9831)	(1.1806)	(0.0241)	

R2 = 0.6613, Normality: JB = 2.9341(0.3010), heteroscedasticity: $\lambda^2(25) = 32.99(0.0840)$
Notes: the values in parenthesis are t-statistics

On the other hand, the various diagnostic tests indicate that the VECM is satisfactorily specified. The Jarque-Bera (JB) statistic shows that the residual are normally distributed, the LM test outlines that there is no residuals up to 4 lags and there is also no problem of heteroscedasticity. The error correction term is significant, showing the existence of long-run causality between the variables. This result of the VECM provides some support for the long-run EKC hypothesis that requires that the estimated long run coefficients for income and its quadratic term alternate in sign starting with a positive. This finding is in line with (Bash, 2015) who found out that there is no evidence of short-run EKC in the economies of Southern African countries but signs of a long run relationship.

Variance Decomposition (VDC) and Impulse Response

The direction of the Granger causality in the sample period and the exogeneity or endogeneity of a variable within the system will be indicated inside the results of the VECM. Conversely, this does not afford us with the dynamic properties of the system as outlined by Rumi Masih (2001). But, the Variance Decompositions (VDCs) and the Impulse Response Functions (IRFs) are used in the determination of the analysis of the dynamic interactions among the variables in the post sample period. The response of the CO_2 emissions ($lnCO_2$) are decomposed to a one standard deviation innovation in the variables' GDP per capita (lnGDP), GDP square ($lnGDP^2$), population density (lnPD) and trade balance (lnTB) within the twenty periods. The graphs of the impulse response functions which are shown in Table 1.5 portray equivalently the information represented in the variance decompositions. Both the VDCs and IRFs are obtained from the moving averages representation of the original VAR model. The IRFs fundamentally indicate the shocks applied to each variables to see its effect on the VAR system.

From the demonstrations in Table 1.5, we can draw from the VDC results the relative information about the significance of each of the random shocks. Observations of the first period indicate that the variation in the $lnCO_2$ is explained 100 percent by its own shock. While looking at the lnGDP variable that has both short-run and long-run significance in the variation of the $lnCO_2$ that accounted for about 7.1 percent within the first 3-period and this value increases to above 11.8 percent during the middle of the

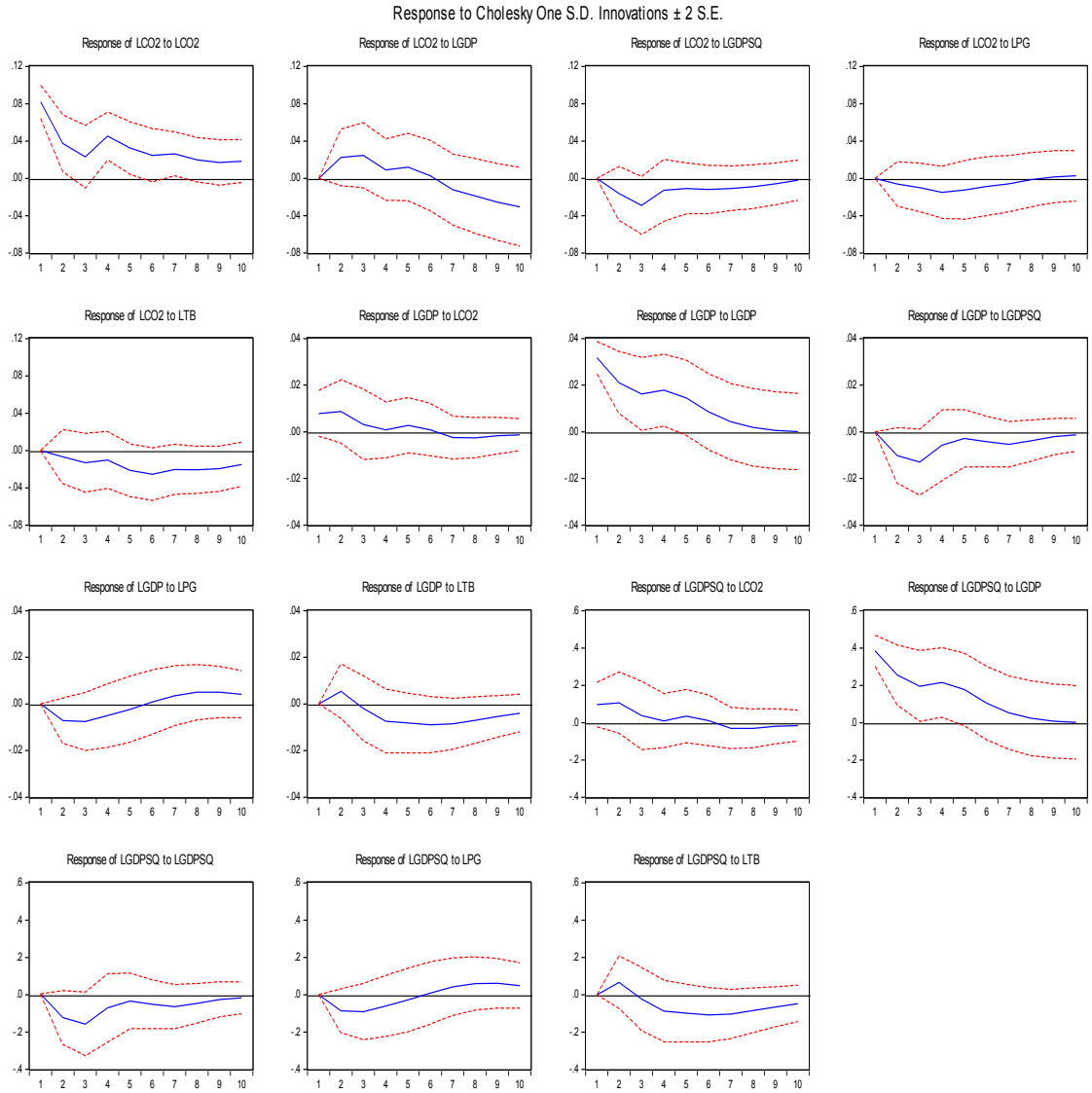
11-period. However, the lnTB variable shows an increase in the percentage of forecast error to over 15 percent in the middle period and slightly reduced to 13 percent in the long period. The lnPD variable shows a percentage of forecast error of about 0.8 percent in the long-run while the lnGDP is showing a little above 14 percent.

Table 1.5: Decomposition of Forecast Error Variance of lnCO2

Period	S.E.	lnCO2	lnGDP	lnGDPSQ	lnPD	lnTB
1	0.070992	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.089448	94.94694	0.890260	0.966978	0.076439	3.119378
3	0.125971	76.72132	7.139430	8.037985	1.051822	7.049446
4	0.171190	75.43952	7.820006	6.109459	2.680380	7.950633
5	0.196770	72.52888	10.03240	5.131041	2.395136	9.912544
6	0.222079	71.16749	10.11296	5.180435	1.962769	11.57634
7	0.251675	71.17631	9.181255	4.573216	1.615826	13.45339
8	0.272846	69.07688	9.935392	4.415666	1.374880	15.19718
9	0.293282	67.89045	10.68008	4.900339	1.191474	15.33766
10	0.313889	68.11600	10.91891	4.706241	1.079014	15.17983
11	0.328778	67.81388	11.54375	4.509244	0.983524	15.14960
12	0.343686	67.90450	11.89828	4.521720	0.900686	14.77482
13	0.361802	68.36243	12.06547	4.348661	0.845567	14.37787
14	0.378736	68.22432	12.63785	4.283279	0.796699	14.05785
15	0.397334	68.11985	13.09270	4.410920	0.790946	13.58558
16	0.418253	68.22156	13.31519	4.342572	0.841484	13.27919
17	0.437129	67.97017	13.67462	4.292068	0.841283	13.22186
18	0.456294	67.70123	13.90650	4.340663	0.833307	13.21830
19	0.476421	67.50389	14.01092	4.300364	0.830009	13.35482
20	0.494303	67.11710	14.24287	4.297190	0.803109	13.53973

In the meantime, trade balance accounted for roughly 7.9 in the short-run and in the longer term, it increases to more than 15 percent in middle period, and dropped to a little above 13 percent. Likewise, the population density contributed only one percent to two percentage points in the short-run and dropped about 0.8 percent in the long-run. This confirms the indications in the long-run relations that the population density has no great significant effect on the CO_2 emissions in The Gambia. The variable trade balance shows an initial increase in the short-run up to the middle term and the decreased towards the long-run which depicts the results of no short-run causality relation between CO_2 emissions and trade openness.

Figure 1.2: Impulse Response Function



The impulse response analysis of the GDP per capita on the growth rate of the CO2 emissions in The Gambia portrays that any shock in these variables causes the GDP square and trade balance to fluctuate within the short run towards the middle term before stabilising in the long run period as shown in Figure 1.2. In the interim, the response of trade balance on the GDP square indicates that depreciation first causes the GDP square to increase in the short run and turn to fluctuate during the medium period before levelling out in the long-run.

Summary Of The Findings

The variables of The Gambian data are from the period of 1966 to 2012. They were firstly, tested for the stationary properties and found to be non-stationary. The initial exploring of the OLS estimation of the linear and quadratic models before proceeding to the main methodology of the study. The results conclude that the EKC hypothesis could not be confirmed in the data set used in this study. Therefore, the Gambian economy being a least developing country with less per capita GDP does not satisfy the threshold to effect any turning point in the inverted U-shaped curve. We employed the ADF and Philips Perrons' tests that show us that all the variables notably, CO_2, GDP per capita, Population density and Trade balance were non-stationary at level but assumed stationary at first differencing. Upon having a stationary property of all the variables at first difference, we proceed with the dynamic causal relationships between the various variables by adopting the Johansen's test of co-integration, Granger's causality tests and the analysis of the Variance decomposition.

Remarkably, the results show the presence of a long-run relationship among the variables and the expectations of the signs show as assumed, and significant at least at 5 percent level. The long run relationship suggests that the GDP per capita, population density positively impacts on the growth of the CO_2 emissions on The Gambia, while the influence of trade balance was seen to be negatively associated. Explicitly, a 1 percent increase in the GDP per capita will generate a rise of 1.2 percent of CO_2 emissions. As for the population density, a 1 percent increase will lead to 2.4 percent of emissions. Finally, the trade balance always shows deficits due to imports and exports imbalances, which indicates a negative impact of 3.7 percent in the CO_2

emissions growth when there is a 1 percent increase in trade balance. The indications of the autonomous variable suggest that if all the variables are held at constant the variation of the shocks will enhance the CO_2 emissions growth to return to the point of equilibrium by the rate of 12 percent.

Apart from the above stated ideas, the results of the Granger causality tests indicate that GDP per capita and Population density causes CO_2 emission growth in the short run in The Gambia, as well as the trade balance causes population density. Therefore, we observed from the Granger causality that there is unidirectional causality running from the GDP to CO_2 emission, from Population density to CO_2 emission, and from trade balance to population density. It was similarly observed that Population density and trade balance do not Granger cause CO_2 emissions in the short run. Likewise, the significance of the Error Correction Term demonstrates the existence of the long run causality between the variables. Nevertheless, the negative sign of the trade balance variable in the VECM shows that trade openness adjusts to equilibrium in the long run. However, the evidence from the findings indicates that the GDP per capita, population density and trade balance are important variables in determining the CO_2 emissions growth in The Gambia.

Furthermore, the results of the variance decomposition (VDCs) and impulse response functions (IRFs) gives us a more detailed analysis in relation to the dynamic interactions between the variables in the post sample period. The results suggest that the contribution of GDP per capita is very significance in the variation of the CO_2 emissions which accounted for about 7.1 percent within the first 3-period and this value increases to above 11.8 percent during the middle of the 11-period and rose to 14.2 percent in the long run term. However, the TB variable shows an increase in the percentage of forecast error to over 15 percent in the middle period and slightly reduced to 13 percent in the long period. The PD variable shows a percentage of forecast error of about 0.8 percent in the long run while the GDP showed a little above 14 percent.

In the meantime, trade balance accounted for roughly 7.9 percent in the short-run and in the longer term, it increases to more than 15 percent in middle period and dropped to a little above 13 percent. Likewise, the population density contributed only one to two percentage points in the short run and dropped about 0.8 percent in the long-run. Referencing from the causal relationship between the variables trade balance, population density, GDP square, GDP per capita and CO_2 emissions growth and relying on our analysis on the variance decomposition and impulse response functions, we can conclusively say that all these variables are in one way or the other significantly related to the emission rate in The Gambia. The shocks of all these variables will enhance the CO_2 emissions growth to return to the point of equilibrium at the rate of 12 percent. Therefore, the effects of the shocks of the variables signify that they have a significant relations in determining the emission level.

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