CARBON DIOXIDE EMISSIONS CONVERGENCE AND INSTITUTIONAL QUALITY IN ECOWAS

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Abstract

This study focused on the relationship between carbon dioxide emissions convergence and institutional quality in ECOWAS[1] between 2002 and 2016. Over this period, the level of CO_2 emissions has been on the rise within the region and it becomes very important to conduct a study of this sort to find out if there exists a convergence of carbon emissions. Six indicators of institutional quality were used in the study as regressors. Both the parametric and non-parametric tests were conducted. The results revealed that voice and accountability, rule of law, and control of corruption have positive impacts on CO_2 emissions convergence while political stability, government effectiveness, and regulatory quality have negative impacts on CO_2 emissions convergence in these countries. Hence, the study recommended that regulatory authorities should strive to design appropriate long-term policies that can enhance institutional quality with the aim of abating CO_2 emissions in the long run.

Keywords: Carbon Dioxide Emissions, Convergence, Institutional quality, ECOWAS.

JEL Classification: O40, Q53, Q56.

1. INTRODUCTION

Over the past decades, various environmental problems have been encountered on the global level. The most prominent of these is global warming and climate change which are the results of greenhouse gas emissions in the atmosphere. These greenhouse gases include Nitrogen, Carbon dioxide (CO_2),

[1] Economic Community of West African States.

Oxygen and Argon of which CO_2 which makes up less than one-tenth of all atmospheric gases is the major contributor to the greenhouse effect. It is essential for human existence. Without it, the earth's temperature will be about 255K $(-18^0\ C)$ and frozen (Scifun, 2017). However, uncontrolled CO_2 emissions throw not only the natural ecosystem off balance, it also disrupts economic activities. According to Sun et al. (2016), there is a strong relationship between the distribution of fossil fuel-related CO_2 emissions and structure of an economy which in turn depends on the country's natural endowments, level of development and its comparative advantage in the production of various commodities.

Over the years, the international community has attached great importance to carbon emissions given its negative impact on the environment. A number of agreements were signed such as the Kyoto protocol in 1997, the Copenhagen Accord in 2009 and most recently, the Intended Nationally Determined Contribution (INDC) in 2015. The INDC is an international climate agreement adopted by countries across the globe which shows their intended post-2020 climate actions; with a long-term goal of achieving net zero emissions in the second half of the century. Nigeria, for instance, committed to end gas flaring by 2030, intensify efforts to encourage reforestation and reduce emissions per capita GDP from 0.873kg CO_2e in 2015 to 0.491kg Co_2e in 2030, amongst others (United Nations Framework Convention on Climate Change, UNFCCC).

The relative impact of governance institutions on increasing carbon dioxide in the global world has been a thing of concern to many researchers. It is observed that as developing countries improve their industrial base so also will their energy needs increase and since the conventional energy sources produce carbon dioxide, the carbon-dioxide emissions of developing nations are at rising rate at that time as the global governance institutions and advocacy are clamouring for a decrease in carbon dioxide emissions. However, in Africa as in many developing countries, without access to cost-effective and abundant energy sources, climate change is seen as a hindrance to unrestricted economic development.

Although institutions in ECOWAS countries aim to foster economic and political integration through promotion and development of member states (Butu, 2013), these countries lack quality institutions such as voice and accountability, political stability and absence of violence, effective government and public administration, rule of law, control of corruption, regulatory quality (WGI[2], 2016) needed to ensure long-term economic development derivable from expansion of their industrial base. For instance, the ECOWAS court of justice which is supposed to sanction member states that violate protocol and court authority has been unable to achieve this. Funding (most member states are not financially buoyant to sustain their needs; hence they depend on developed countries), corruption, lack of political will and stability are some of the major bottlenecks that constitute constraints to ECOWAS institutions.

[2]Worldwide Governance Indicators

Also, it is widely observed that relatively stringent regulations are needed to reduce hazardous emissions. Irrespective of the medium to achieve this whether, through direct controls, economic instrument, voluntary industry agreement etc., legitimate measures are still expedient for these regulatory measures to be effective. This is a serious concern in developing countries, who often struggle to achieve eradication in both poverty level and environmental pollution (Dasgupta, shymsundar and Maler, 2004). According to UNICEF (2016), the proportion of pollution emissions in Africa is changing as a result of increasing industrial production, urbanization and traffic. For instance, in Nigeria, there has been a rise in CO_2 emissions from 0.07billion tonnes in 1990 to 0.10billion tonnes of CO_2 in 2001. This has increased to 0.23 billion tonnes of CO_2 in 2015 (Global emission, 2016). According to the Global Burden of Disease (2013), for every 100,000 people, 31.5% die from air pollution in low and middle-income countries, compared with 0.5% in high-income countries. Incidentally, these are countries with weak institutions and environmental laws. World Health Organization (2014) argued that outdoor air pollution is highest in both Asia and Africa as a result of increased movement of industrial production from high-cost countries to developing countries called pollution havens with a lower cost of production. Also, Anoruo (2014) stated that at early stages of development in developing countries, there is intense pressure on the environment; hence it deteriorates. This increases environmental pollution through emissions from increased industrial activities. This further leads to a catch-up effect with richer countries in CO_2 emissions.

This study, therefore, intends to investigate the relationship between carbon dioxide emissions convergence and institutional qualities in ECOWAS countries. It shall go further to investigate the impact of governance or political institutions on carbon dioxide emissions in these countries. In order to achieve this objective, it is imperative that specific objectives include the determination of the presence of carbon dioxide emissions convergence in ECOWAS countries and the impact of governance institutions (such as law and order, control of corruption, etc.) on carbon dioxide emissions in selected ECOWAS countries.

The rest of the paper is structured as follow. Section 2 reviews the relevant literature. Section 3 discusses the methodology and the description of the data, while section 4 presents the empirical results. Section 5 concludes with policy implications.

2. REVIEW OF RELEVANT LITERATURE

2.1. THEORETICAL REVIEW

This section aims at discussing the various theories of pollution and carbon dioxide emission convergence. They include but are not limited to the Pollution Haven Hypothesis, environmental Kuznets curve hypothesis, ecological dumping hypothesis, environmental externality theory and the environmental convergence hypothesis.

2.1.1. The Pollution Haven Hypothesis

The Pollution Haven Hypothesis (PHH) states that as a country grows and develops, its pollution concentration rises. However, because of stringent environmental regulations that come with industrialization, the country uses its increasing wealth to reduce pollution concentrations by relocating to areas with less severe environmental regulations. In other words, large industrialized countries in an attempt to reduce production costs associated with meeting high environmental standards set up factories in areas with weaker environmental policies, usually poorer countries to produce pollution-intensive goods. These factories or areas relocated to are termed pollution havens.

Country-specific characteristics include country's endowment in terms of factors of production, its various production technologies, etc. These characteristics given world prices determine national income. Given that national income has increased, pollution is expected to be on the rise leading to the adoption of stringent environmental regulations to protect the environment. This could be in form of implementation of pollution taxes. This tax invariably affects the costs of production in the economy which translates to prices. Since there are no impediments to trade and foreign direct investment (FDI) flows, these countries seek refuge in poorer countries with more friendly environmental regulations; thereby protecting their environment and increasing emissions in the recipient countries. The PHH standard model is given as:

$$Y_{i,t} = \alpha R_{i,t} + \beta_1 X_{i,t} + \varepsilon_{i,t} \quad (1)$$

Where Y is economic activity; R is regulatory stringency; X is an aggregate of other characteristics that affect Y and εε is the error term. This equation implies that as R changes, Y responds negatively, that is, environmental regulations and economic activities are negatively correlated. This is because the production of pollution-intensive goods becomes more costly as regulations increase, therefore reducing the comparative advantage of the goods. This causes firms to move to countries with lower environmental standards thereby decreasing Y.

If the above is true, it means that as income increases in industrialized countries, pollution concentration rises, and as cost becomes unbearable, countries relocate to safe havens to reduce emissions of harmful gases. This looks like the Environmental Kuznets model which suggests that a country's pollution concentration rises with the industrialization process up to a certain point after which it falls again as the country uses its increased wealth to reduce pollution concentrations. Furthermore, cleaner environment in developed countries come at the expense of dirtier environment in developing countries. This brings us to the concept of Environmental Kuznets Curve (EKC) hypothesis.

2.1.2. Environmental Kuznets Curve Hypothesis

The Environmental Kuznets Curve concept (EKC) emerged in the early 1990s with Grossman and Krueger's path-breaking study of the potential impacts of NAFTA. Kuznet (1955) suggested that in the early stages of economic growth, the distribution of income will tend to worsen; only at later stages will it improve. This observation is characterized by the inverted-U Kuznets curve which shows the relationship between a country's per capita income and its equality of income distribution. Kuznets's explanation for worsened inequality at early stages of economic growth was related to structural changes in an economy as it develops from a traditional to a modern economy. This can be broken down as:

i) The scale of production implies expanding production at given factor-input ratios, output mix and state of technology;
ii) The pollution intensities of industries differ across countries, which change the output mix as economic development changes;
iii) Changes in input mix include the replacement of less environmentally damaging inputs for more damaging inputs and vice versa;
iv) Enhancements in the state of technology include changes in both:
    a) Production efficiency in terms of using less polluting inputs per unit of output,
    b) Emissions specific changes in process results in fewer pollutants being emitted per unit of input.

There is convincing evidence that the inverted-U relationship holds for some local pollutants such as particulate matter in the air, carbon dioxide, sulfur dioxide and nitrogen oxides. The earliest EKCs were simple quadratic functions of the levels of income. The standard EKC regression model is given as:

$$ln(E/P)_{i,t} = \alpha_i + \gamma_t + \beta_1 \, ln(GDP/P)_{i,t} + \beta_2 \left(ln(GDP/P)\right)^2_{i,t} + \varepsilon_{i,t} \qquad (2)$$

Where E represents emissions and P is population. The intercept parameters are given by the first two terms on the right-hand side. They vary across countries i and years t. The assumption is that though the level of emissions per capita may differ over countries at any particular income level, the income elasticity is the same in all countries at a given income level. The time varying omitted variable and stochastic shocks that are common to all countries are capture by the time specific intercepts.

2.1.3. The Environmental Dumping Hypothesis

The Environmental Dumping Hypothesis says that countries with strict environmental laws transfer their wastes to countries with less strict environmental laws in order to benefit from cheap disposal and recycling of wastes. This transfer of waste is referred to as transfrontier shipment of waste. The wastes could be generated by households, firms, and industries. Generally, there are hazardous and non-hazardous wastes. Hazardous wastes include lead pollutants which are harmful to human existence while non-hazardous wastes include metal, paper and plastic products.

The wastes shipped are divided into three separate lists based on the waste shipment regulation, which include:

i. Red List- This list is made up of very harmful materials. They include dioxins, polychlorinated biphenyl, batteries, etc.
ii. Amber List- This list consists of a mixture of both non-hazardous and hazardous materials. They include organic & inorganic wastes, metal bearing wastes, etc.
iii. Green List- This list contains wastes that are non-hazardous and more environmentally friendly. They include materials like plastic and paper that can be recycled.

2.1.4. Environmental Externality Hypothesis

The theory of environmental externalities was advanced by Pigou (1920). An externality is the consequence of an economic activity that is borne by a third party, which could be positive or negative. The theory of economic externality examines the cases where the costs or benefits of the activities extend beyond the parties directly involved and third parties are impacted. A positive externality is a benefit that accrues to an unrelated third party as a result of an activity carried out while negative externalities are negative effects that originate during the production process of a good or service; or while carrying out an activity. An example of a negative externality is air pollution from burning fossil fuels, anthropogenic climate change as a result of greenhouse gas emissions from burning fossil fuel, water pollution by industries that harm plants and livestock, etc.

Pigou proposed a solution to negative externalities through his ‘pollution pays principle’. He studied smoke emitted by a factory and its damaging impact on businesses and residents. The solution was to impose a per unit tax on the output of the firm generating the negative externality. This is known as the Pigovian tax. The per unit tax should be equal to the difference between the social marginal cost and the private marginal cost corresponding to the social optimal output, with the output satisfying price equals social marginal cost conditions. He said that imposition of taxes will increase the prices of output and reduce demand thereby aiding consumers and producers of the product in factoring in environmental costs. Pigou, however, recognized that government involvement and authoritative control are needed in case of complications.

2.1.5. The Environmental Convergence Hypothesis

The concept of convergence was originally developed to show that the inequality in economic growth between countries and regions should reduce over time. In general, convergence is the tendency for different systems to evolve towards performing similar tasks. It is referred to as 'the catch-up effect'. The environmental convergence hypothesis splits convergence into two different approaches. The first definition is based on cross-section data in which convergence is derived from classical growth literature namely: Beta (β) and Sigma (γ) convergence while the other definition is stochastic convergence based on the time series approach.

Beta-convergence is a catching-up effect that occurs when the emissions of poor developing countries, with lower initial levels of emissions per capita, tend to grow faster than those of capital rich developed countries. This approach assumes that all countries converge towards a common steady-state level of carbon dioxide emissions. The ability of poorer countries to replicate developed countries mode of production and technologies; and the establishment of pollution havens in poorer countries has been linked with reasons for this type of convergence. Absolute beta convergence can be tested using the following equation:

$$ln\left[\frac{Y_{i,t}+K}{Y_{i,t}}\right] = \propto\ + \beta_1\, ln\left(Y_{i,t}\right) + \ \varepsilon_{i,t} \qquad (3)$$

Where $\ln\left[\frac{Y_{i,t}+K}{Y_{i,t}}\right]$ is the mean annualized growth rate of the variable Y in country i in the period $(t, t+k), Y_{i,t}$ is the value in the initial time, t and $\varepsilon_{i,t}$is the corresponding residual. Here, Y represents per capita CO_2 emissions. For beta convergence to exist, the growth rate of $Y_{i,t}$ must be negative (positive) if the initial value of $Y_{i,t}$ is positive (negative). In other words, $\propto$ and β must produce dissimilar signs (Tiwari and Mishra, 2017). However, the beta convergence is limited by its assumption of linearity in growth rate and impossibility to detect club convergence.

Sigma convergence refers to a reduction in the dispersion of levels of carbon dioxide emissions across economies. The presence of beta convergence does not guarantee sigma convergence. Sigma convergence is usually measured either by the coefficient of variation or standard deviation in two different time periods. If it tends to decline over time, it is evident that there is convergence across the countries because the variability or dispersion is decreasing.

Convergence is said to be stochastic if unit root test from panel or time series data is found to be trend stationary.

2.2. EMPIRICAL REVIEW

Acar *et al.* (2017) investigated the implications and meta-analysis of per capita CO_2 emissions convergence over the period 2003 to 2014. 22 different empirical studies on CO_2 emissions convergence were collected across countries. Their relationships were observed using the logit model in the meta-analysis. Results showed that CO_2 emissions convergence is mostly supported for the industrial countries but not for the world as a whole. This means that CO_2 emissions divergence was observed at the global level. Anoruo (2014) carried out a panel study across 15 African countries to test for the existence of stochastic convergence in per capita CO_2 emissions over the period 1971 to 2011. The sequential panel selection method was employed for this analysis. To overcome the shortcomings of previous panel unit root tests, the KSS unit root test and Fourier functions were used to examine the presence of convergence. Findings revealed convergence in per capita CO_2 emissions across the countries as a whole. However, individual countries like Congo, Zambia, Egypt, and Botswana experienced divergence from the sample average emissions.

Brännlund et al. (2015) analyzed the convergence of carbon dioxide performance across Swedish industrial; sectors using the environmental index approach which accounted for industrial firms producing good as well as bad outputs. The study employed a dataset covering 14 industrial sectors over the time period 1990 to 2008. Results revealed the presence of conditional β-convergence in CO2 performance among the industrial sectors in Sweden. Furthermore, the speed of convergence showed that the higher the capital intensity, the lower the convergence rate to the different steady states. Burnett (2013) examined the club convergence and clustering of energy-related CO2 emissions among a panel of US states between the periods of 1960 to 2009. The states were divided into 2 groups namely; the high-emitting group and medium-emitting group. The log t-test, also known as the asymptotic co-integration test was used to test for convergence given heterogeneity within the panel data. Results showed that the 2 group of states converged to similar growth paths.

Herrerias (2013) investigated the environmental convergence hypothesis in CO2 emissions for a group of developed and developing countries from 1980 to 2009 according to the sources of energy (coal, oil, and gas). The pair-wise test was used to test for convergence hypothesis and existence of club convergence. Results showed that CO2 emissions for each type of energy diverged while club convergence was found for most of the countries. Huang and Meng (2013) analyzed the convergence of per capita carbon dioxide emissions in urban China from a spatiotemporal perspective over the period 1985-2008. The convergence hypothesis test was carried out using Moran's I statistics to detect global spatial dependence of per capita emissions in the urban China. Results showed that during the period, per capita CO_2 emissions in these areas increased and converged, indicating a “catching up” in the emission of CO_2 in China. Furthermore, the study recommended that the Chinese government ensures that policy measures on environmental protection actually reduce CO_2 emissions.

Jalil (2016) examined the convergence of per capita CO_2 emissions for 126 developing countries in Africa, Latin America and the Caribbean, as well as Asia and the Pacific regions from 1971 to 2009. The log t-test was adopted for this study based on the methodology proposed by Phillips and Sul (2007). Results showed that developing countries per capita CO_2 emissions levels converged over the period indicating the need for developing countries to participate in emission control policies. Jobert et al. (2010) investigated whether there is an actual convergence of per capita CO_2 emissions in 22 European countries over the period 1971 to 2006. The Bayesian shrinkage estimation method was employed in this study. Results showed that there is absolute convergence in per capita CO_2 emissions in the region, countries differed in terms of speed of convergence and volatility of income; and finally, that as GDP increases, there is expected an increase in per capita emissions.

Li et al. (2017) examined the relationship among carbon emissions, economic growth and three different types of fossil energy consumption (coal, oil, and gas) using time series data from China over the period 1965-2015. The vector error correction model and Granger causality tests were employed in the analysis purpose. Findings revealed the existence of bidirectional causalities between GDP and coal consumption, GDP and gas consumption and between coal consumption and CO_2 emissions and unidirectional causalities running from GDP and oil consumption to CO_2 emissions, from GDP to oil consumption and from coal consumption to oil and gas consumption. Lindmark and Acar (2015) examined the convergence of CO_2 emissions caused by oil combustion for a panel of 86 countries from 1973 to 2004 laying emphasis on the importance of analyzing several sub-periods separately. The cross-sectional β-convergence model was adopted and analyzed using the sample OLS approach. Findings revealed that there was β-convergence of CO_2 emissions intensity due to oil combustion for the sub-periods 1973 to 1979 and 1979 to 1991 while post-1991 periods showed no evidence of convergence. Ozcan and Gultekin (2016) examined the presence of the stochastic convergence hypothesis in relative per capita CO_2 emissions in 28 OECD countries for the period to 2013. The two-break LM and three-step RALS-LM unit root tests were employed for analysis. Results showed evidence of convergence in the two breaks while without structural breaks, there appeared to be a divergence in emissions.

Pettersson et al. (2014) reviewed previous research works on CO_2 emissions convergence among countries. Overall, results showed evidence of CO_2 emissions convergence amongst developed OECD countries while there appeared to be a relatively persistent gap or divergence at the global level. The study, however, recommended additional research on the structural determinants of carbon intensity at the country level. Sun et al. (2016) attempted to test the validity of CO2 emissions convergence in the 10 largest economies of the world namely; US, China, Japan, Germany, France, UK, Brazil, Italy, India, and Canada over the period 1971 to 2010. The unit root test for stationarity was adopted using the Fourier function proposed by Enders and Lee (2012). Findings revealed that CO2 emissions levels converged in most of the countries regardless of their development pattern. The study further recommended that the efforts should be intensified to reduce emissions in the US, Japan, and Germany because of high levels of emissions observed.

Tiwari and Mishra (2017) tested for CO2 emissions convergence across 18 developed and developing Asian countries over the period 1972 to 2010. The parametric and non-parametric convergence tests were adopted using the beta and sigma convergence and the Kernel density estimates respectively. Results showed evidence of CO2 convergence in the countries although initial periods of convergence did not depend on the previous period; that is, they varied while recent years experienced a decline in variation. The study further recommends that per capita emission allocation schemes be adopted in order to curb increasing emissions.

Wang and Zhang (2013) investigated the presence of CO2 emissions convergence in different sectors in China while taking cognizance of factors that impacted convergence in each sector. 6 sectors were studied across 28 China provinces from 1996 to 2010. The panel unit root test and OLS method of estimation were used to test for the beta, sigma, and stochastic convergence. Results showed that per capita CO2 emissions converged across all the sectors in the provinces. Also, factors that affected convergence in each sector included GDP per capita, industrialization process, trade openness and population density although they varied across the sectors. Wu and He (2017) analyzed the distribution dynamics of CO2 emissions intensity across 30 Chinese provinces using a biased distribution dynamic approved over the sample period of 1995 to 2014. Analysis of dispersion was carried out using the coefficient of variation and it was observed that the coefficient kept increasing over the period. This showed that the country has a dispersion trend mainly driven by an increase of CO2 emissions intensity in the western region relative to the eastern and central regions. Furthermore, the results revealed that asides divergence, polarization, and stratification are the dominant characteristics in the distribution dynamics of CO2 emissions intensity across Chinese provinces.

Zhao et al. (2014) examined carbon emissions convergence intensity at the provincial level in China over the period 1990-2010. The spatial dynamic panel data model was used to test for absolute beta convergence and conditional β-convergence in the 30 provinces. Findings revealed that carbon emissions intensities converged across the provinces and the rate of conditional β-

convergence is higher than that of absolute β-convergence, amongst other observations.

3. RESEARCH METHODOLOGY

3.1. THEORETICAL FRAMEWORK

This study adopts the environmental convergence hypothesis as its theoretical framework, based on the work of Panopoulou and Pantelidis (2009), to determine the threshold of carbon emissions convergence in ECOWAS countries. The model postulates that all countries converge towards a common steady level of CO_2 emissions as poorer countries level of emission catch up with those of capital rich developed countries. The first objective of this study is to determine the threshold of CO_2 emissions convergence amongst ECOWAS countries. This can be calculated using the absolute beta convergence equation. It is given as:

$$ln\left[\frac{Y_{i,t}+K}{Y_{i,t}}\right] = \propto \; + \beta_1 \, ln\left(Y_{i,t}\right) + \; \varepsilon_{i,t} \qquad (4)$$

Where ln $\left[\frac{Y_{i,t}+K}{Y_{i,t}}\right]$ is the mean annualized growth rate of the variable Y in country i over the sample period.$Y_{i,t}$ is the value in the initial time, $\varepsilon_{i,t}$is the corresponding residual, and Y represents the per capita CO_2 emissions.

The second objective of this study tests for the impact of governance institutions on CO_2 emissions convergence. To achieve this, CO_2 emissions convergence is expressed as a function of voice and accountability, political stability and absence of violence, effective government and public administration, rule of law, control of corruption and regulatory quality.

Based on the works of Tiwari and Mishra (2017), this study makes use of both parametric and non-parametric test to capture its first objective. This is because of the shortcomings of parametric tests which include unreal generalizations and lack of flexibility. Non-parametric tests also test for possible short-term divergence trends in CO_2 convergence process.

3.1.1. Parametric Models of Convergence

Absolute Beta Convergence

This approach assumes that all countries converge towards a steady state of CO_2 emissions level. That is, the gap between rich and poor countries CO_2 emissions fades out as poor countries start to progress and develop. Absolute beta convergence is tested using the equation below:

$$ln\left[\frac{Y_{i,t}+K}{Y_{i,t}}\right] = \propto \ + \beta_1 \, ln\left(Y_{i,t}\right) + \ \varepsilon_{i,t} \tag{5}$$

Where $\ln\left[\frac{Y_{i,t}+K}{Y_{i,t}}\right]$ is the mean annualized growth rate of the variable Y in country i over the sample period.$Y_{i,t}$is the value in the initial time, $\varepsilon_{i,t}$is the corresponding residual, and Y represents the per capita CO_2 emissions.

Beta convergence exists when countries with initial emissions below the average emission exhibit faster growth than countries with initial emission above the average emission rate. Hence, the existence of beta convergence is ascertained if $\beta < 0$.

3.1.2. Non-Parametric Convergence Models

Due to the weaknesses of the parametric test, there is a need for non-parametric estimation of CO2 emissions convergence. Among the non-parametric estimates which include but are not limited to the histogram, kernel density estimation, data envelopment analysis and KNNs, the kernel density estimation will be adopted in this study because of its smoothness, ability to provide better estimates and converge faster.

3.1.2.1. Kernel Density Estimation

The kernel density estimation is also known as the Parzen-Rosen Blatt window method is a non-parametric test to estimate probability density function of a random variable. It is a fundamental data smoothing problem where inferences about the population are made based on a finite data sample. In order to minimize the mean integrated square error in deriving the smoothing parameter, this study adopts the Gaussian kernel approach using the following equation:

$$f(x) = \frac{1}{hn} {}_{i=1}^{\ n}\Sigma k \left[\frac{x - X_i}{h}\right] \tag{6}$$

Where f(x) is the density estimation of the variable x, n is the number of observations, h is the smoothing parameter (bandwidth), and k is the smooth and symmetric kernel function integrated to one.

To capture our second objective after determining the threshold of convergence, a panel co-integration test will be carried out after having tested for stationary of the variables involved. Panel co-integration is appropriate for this study because it handles both large cross-sectional dimension (large N), large time series dimension (large T) and has the ability to eliminate spurious regression and co-integration.

3.1.2.2. Panel Test

The panel unit root test is conducted and has been found to be advantageous over the conventional unit root tests. It helps to explore the characteristics of the data involved before embarking on panel co-integration test. The idea is to test for the stationarity of variables used in the study. This study specifically made use of the homogeneous panel unit root test (Levin, Lin and Chin, Philips and Perron, and Fisher Chi-square tests). This is done in order to exploit the extra power in the cross-sectional dimension of the data.Once the stationarity test is conducted, there is need to test the relationship that exists among variables. This test is carried out to check for the presence of long-run relationship among integrated variables. The Pedroni's residual cointegration test rejects the null of no co-integration when they have large negative values except for the panel-v test which rejects the null of the co-integration relationship between the variables.

Once co-integration test has been conducted, we employ the Wald test of co-efficient restrictions to determine whether the Pooled Effect Model is preferable or not to the fixed and random effect model. The Wald test tests the joint significance of the country-specific effects by testing that all the coefficients are not significantly different from zero. Rejection of the null hypothesis implies that there exist country-specific fixed and random effects. The Hausman test is carried out to determine whether fixed effect model or random effect model would be appropriate for the panel of the countries. The null hypothesis of the Hausman test is that the fixed effect model (FEM) and random effect model (REM) do not differ substantially and its rejection implies fixed effect model would be appropriate.

3.2. MODEL SPECIFICATION

To determine the relationship between CO_2 emissions convergence and institutional qualities in ECOWAS, firstly, we adapt the model used by Tiwari and Mishra (2017) in determining the existence of beta and stochastic CO_2 emissions convergence. As stated before, the beta convergence model is given as:

$$ln\left[\frac{Y_{i,t+k}}{Y_{i,t}}\right] = \propto \ + \beta_1 \, ln(Y_{i,t}) + \ \varepsilon_{i,t} \tag{7}$$

Where $\ln\left[\frac{Y_{i,t+k}}{Y_{i,t}}\right]$ is the mean annualized (average) growth rate of CO2 emissions in country i over the sample period, $Y_{i,t}$is the initial level of CO2 emissions for country i, and $\varepsilon_{i,t}$ is the error term. The existence of beta convergence is ascertained if β<0. Thereafter, we test for the significance of institutional qualities on CO2 emission convergence. We have:

$$CO_2EC = \beta_0 + \beta_1 VAC + \beta_2 POS + \beta_3 EGA + \beta_4 ROL + \beta_5 COC + \beta_6 REQ + U_i \quad (8)$$

Where CO_2EC is carbon dioxide emission convergence, VAC is voice and accountability, POS is political stability and absence of violence, EGA is effective government and public administration, ROL is rule of law, COC is control of corruption, and REQ is regulatory quality.

3.3. SOURCES AND MEASUREMENT OF DATA

The data used in this study have been drawn from a panel set covering 15 ECOWAS countries namely, Benin, Burkina Faso, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo over the period 2002 to 2016. All the data used in this research study is secondary in nature and data archive of World Bank Development Indicators was used to gather a sample of 15 years from the year 2002 to 2016. The Nigerian webpage of the World Bank was used to download comprehensive excel based data bank.

4. EMPIRICAL RESULTS AND INTERPRETATION

4.1. PARAMETRIC NON-PARAMETRIC MODELS OF CONVERGENCE

Table 1: *Absolute Beta Convergence of CO_2 Emissions in ECOWAS*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0062	0.0185	0.3335	0.7390
ln$Y_{i,t}$	-0.0083	0.0113	-0.7322	0.4648
R-squared	0.0023			
Adj. R-squared	-0.0020			

Source: Authors' Compilation.

In table 1, the absolute Beta convergence result confirmed that the a priori expectation is met by CO_2 emissions in ECOWAS countries. Although the value is statistically insignificant, the coefficient of Y_t is negative, which implies that CO_2 emissions for the ECOWAS countries converge over the period under study. Hence, we proceed with the non-parametric test using the Kernel density estimation to further confirm our result.

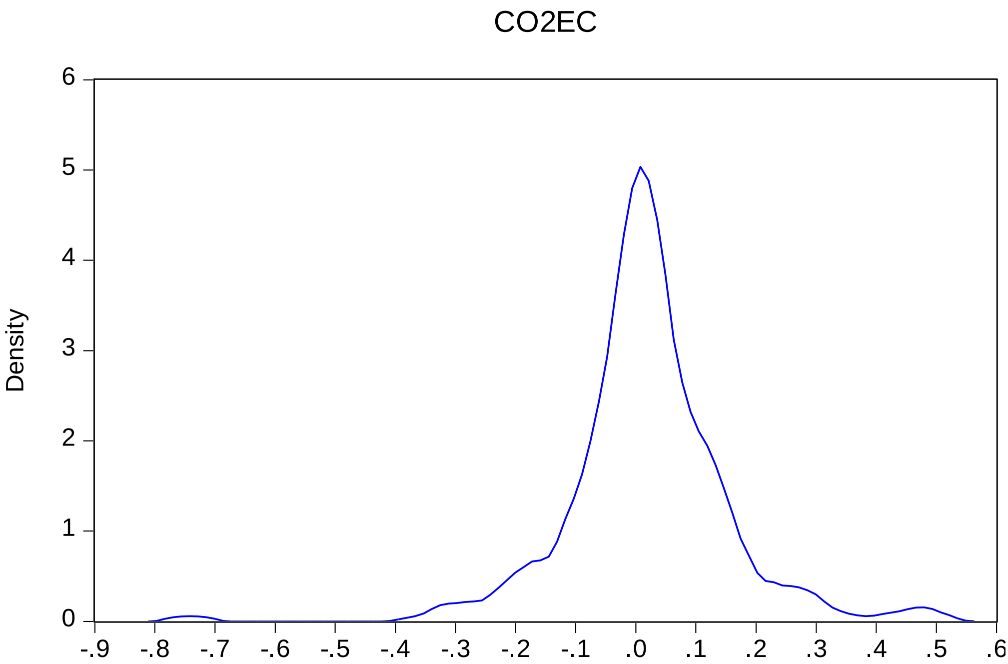

Figure 1. *Kernel Density test of CO_2 Emissions Convergence in ECOWAS*

In figure 1, the Kernel Density is normally distributed. This shows evidence of convergence in CO_2 emissions across ECOWAS countries. Also, it is clear that the mass of highly peaked and right-skewed carbon density from 2002 to 2016 tends to migrate toward larger CO_2 emissions per capita. In empirical studies, different results have been obtained for different groups of countries, especially for developed countries. However, in case of ECOWAS countries, which are mostly developing countries, there exists carbon emissions convergence.

4.2. PANEL UNIT ROOT TEST RESULTS

The results of the Unit root tests are shown in table 2. The Levin, Lin and Chu t* test for common unit root as well as the Phillips-Perron test for individual unit root were carried out at 1%, 5% and 10% critical levels. The results indicate that all the variables were stationary at first difference at 1%, 5% or 10% significance level. That is, none of the variables possess unit root either individually or as a group. This implies that the seasonal variation of the variables has been corrected for, thus making them fit for regression analysis.

Table 2. *Unit Root Test Results at first difference.*

Variables	Levin, Lin and Chu t* statistic	*PP-Fisher Chi-Square test statistic*	*Result*
CO_2EC	-6.2221(0.0000)***	158.001 (0.0000)***	Stationary
VAC	-5.3475 (0.0000)***	138.282 (0.0000)***	Stationary
POS	-9.2668 (0.0000)***	174.075 (0.0000)***	Stationary
EGA	-3.8128 (0.0001)***	64.0395 (0.0003)***	Stationary
ROL	-4.3532 (0.0000)***	133.432 (0.0000)***	Stationary
COC	-5.1262 (0.0000)***	125.072 (0.0000)***	Stationary
REQ	-6.5617 (0.0000)***	137.031 (0.0000)***	Stationary

Note: Probabilities are in parentheses. ***, imply the rejection of the null hypothesis of unit root at 1%, significance level.
Source: Authors' Compilation.

4.3. PANEL CO-INTEGRATION RESULT

Having confirmed that the panel variables are stationary at first difference, rather than at levels, we proceed further to conduct the panel co-integration test. This is to ascertain the long run relationship between the institutional quality variables and CO_2 emissions convergence in ECOWAS. In doing this, we employ four tests that are within group and three tests that are between group to find out whether there is a long run relationship among the panel data employed in the study. This is shown in table 3. The columns in table 3 labeled as within-dimensions contain the statistics' computed value on the basis of the estimators that pool the autoregressive coefficient across the different countries in the panel for the unit root tests on the estimated residuals.

Table 3. *Pedroni Residual Co-integration Test.*

Within-Dimension			**Between-Dimension**	
	Statistics	**Weighted Statistics**		**Statistics**
Panel v	-5.9106**	-3.7829*	**Group rho**	-4.6362**
Panel rho	2.8217	-4.0996**	**Group PP**	-11.5454***
Panel PP	-9.2819***	-7.2050***	**Group ADF**	0.4744
Panel ADF	-6.2349**	0.0134		

Note: ***, ** and * indicate 1%, 5% and 10% level of significance.
Source: Authors' Compilation.

In table 3, the columns labeled within-dimension report that the estimators are statistically significant with the exception of the panel rho that is statistically insignificant. Also, the between-dimension reports the computed value of the statistic on the basis of average individually calculated coefficients for every country in the panel and it shows that except for the group ADF, the between-group test shows that the null hypothesis of no co-integration is rejected.

4.4. TEST FOR POOLED, FIXED OR RANDOM EFFECT MODEL

The Wald test of coefficient restrictions is employed to determine whether the Pooled Effect Model is preferable or not to the fixed and random effect model. The Wald test tests the joint significance of the country-specific effects by testing that all the coefficients are not significantly different from zero. Rejection of the null hypothesis implies that there exist country-specific fixed and random effects. The results of the Wald test are displayed in table 4.

Table 4. *Wald Test.*

Test Statistic	Value	Df	Probability
F-statistic	0.8762	(7, 218)	0.5260
Chi-square	6.1339	7	0.5242

Source: Authors' Compilation.

The Wald test result presented in table 4 confirms that the probability of the F-statistic is insignificant at 5% level of significance. Hence, we reject the null hypothesis and conclude that there exist country-specific effects. To this end, we then conduct the Hausman test to determine which of fixed and random effect model is more suitable for this study.

The Hausman test is carried out to determine whether fixed effect model or random effect model would be appropriate for the panel of the ECOWAS countries. The null hypothesis of the Hausman test is that the fixed effect model (FEM) and random effect model (REM) do not differ substantially and its rejection implies fixed effect model would be appropriate. The test is carried out using the control independent variable and the explanatory variables. Therefore, the result of the Hausman test is reported in table 5. This means that if the result of the Hausman test is significant, then, the fixed effect model is preferable, but if it is not significant, then, the random effect model is more appropriate.

Table 5. *Hausman Test.*

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Probability
Cross-section random	11.471883	6	0.0748

Source: Authors' Compilation.

In the Hausman test result presented in table 5, it is reported that the Hausman test statistic is not significant at 5% level of significance. This implies that the random effect model is more appropriate in this study. To this end, we proceed to report the result of the random effect model in table 6.

Table 6. *Empirical Result from the Random Effect Model.*
Dependent Variable: CO_2EC

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0216	0.0215	1.0072	0.3149
VAC	0.0978	0.0267	4.0948	0.0084
POS	-0.0037	0.0171	-0.2192	0.8267

EGA	-0.0069	0.0471	-0.1464	0.8837
ROL	0.0176	0.0580	0.3050	0.7606
COC	0.0112	0.0291	0.3840	0.7013
REQ	-0.0189	0.0508	-0.3728	0.7096
R-squared	0.6354			
Adj.R-squared	0.5418			

Source: Authors' Computation.

4.5. DISCUSSION OF RESULTS

In table 6, the effect of institutional qualities in ECOWAS countries on CO_2 emissions convergence is presented. In the result, the initial value of carbon emission convergence per capita is 0.0216 when all the explanatory variables are kept constant. In the result, voice and accountability, rule of law, and control of corruption have a positive impact on CO_2 emissions convergence while political stability, government effectiveness, and regulatory quality have a negative impact on CO_2 emissions convergence in ECOWAS. In the result, one percent increase in voice and accountability caused the CO_2EC to rise significantly by about 9.7% while holding constant all the other explanatory variables.

The result of this study is well situated in the literature as it has confirmed some of the results of previous studies such Avila (2007), Barassi *et al* (2011), Burnett (2013), Chang and Lee (2008), Huang and Meng (2013), which found that there is the existence of convergence in their various studies. Furthermore, one percent increase in the rule of law caused the CO_2EC to rise by about 1.7% while holding constant all the other explanatory variables. Again, one percent increase in control of corruption caused the CO_2EC to rise by about 1.1% while holding constant all the other explanatory variables. However, one percent increase in political stability caused the CO_2EC to fall by about 0.3% while holding constant all the other explanatory variables. Also, one percent increase in government effectiveness caused the CO_2EC to fall by about 0.6% while holding constant all the other explanatory variables. Also, one percent increase in the regulatory quality caused the CO_2EC to fall by about 1.8% while holding constant all the other explanatory variables. One striking result of note in this study is that it is only voice and accountability that is significant in explaining changes in CO_2 emissions convergence among the ECOWAS countries. The R-squared value signifies that about 63% of the variation in CO_2 emissions convergence is jointly accounted for by all the institutional variables, while the adjusted R-squared suggests that after removing the effect of insignificant regressors, the explanatory variables jointly accounted for about 54% of the variation in the dependent variable. Therefore, the model is a good fit. Finally, this present study confirmed the results of Criado and Grether (2009), Brannlund *et al* (2015), Lindmark and Acar (2015), and Tiwari and Mishra (2017), which empirical results revealed the presence of conditional β-convergence in CO_2 performance among the industrial sectors.

5. CONCLUSION AND POLICY RECOMMENDATIONS

5.1. CONCLUSION

The relationship between CO_2 emissions convergence and institutional qualities in ECOWAS between 2002 and 2016 covers a period of fifteen years. The estimated regression results revealed that long-run relationship exists between carbon emission convergence and institutional quality among ECOWAS countries. Furthermore, it was confirmed that voice and accountability, rule of law, and control of corruption have a positive impact on CO_2 emissions convergence while political stability, government effectiveness, and regulatory quality have a negative impact on CO_2 emissions convergence in ECOWAS countries. However, most of the institutional quality variables were not significant in explaining CO_2 emissions convergence in ECOWAS. To this end, we conclude that institutional quality has an insignificant long-run relationship on CO_2 emissions convergence in ECOWAS countries.

5.2. POLICY RECOMMENDATIONS

Considering the result of the relationship between CO_2 emissions convergence and institutional quality in ECOWAS, the following policies are recommended in the study:

i. The various governments in ECOWAS should put in place appropriate measures that can ensure the reduction of CO_2 emissions in the region.
ii. Since it has been established that long-run relationship exists between CO_2 emissions convergence and institutional qualities in ECOWAS, it becomes expedient for regulatory authorities in the region to maximize this opportunity to design appropriate long-term policies that can enhance institutional qualities with the aim of abating CO_2 emissions in the long run.
iii. Individual country in ECOWAS should also strive to ensure that the quality of institutions is non-negotiable as this is the only means by which sustainable development can be made a reality.

Further research may contribute to the existing knowledge by having a look into the appraisal of institutional quality on economic convergence in ECOWAS. They may also be geared towards looking at the relationship between institutional quality and sustainable development in Africa.

Finally, studies can also be directed towards looking at the impact of the effect of resource abundance and institutional quality on the environment in ECOWAS.

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