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# TESTING THE ENVIRONMENTAL KUZNET CURVE IN SELECTED WEST AFRICAN COUNTRIES: EMPIRICAL EVIDENCE ESTIMATION

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**ABSTRACT:** *Environmental economics studied has become increasingly most popular in local and international communities. This is due to the fact that we are currently facing pressing issues about climate change effects in our planet. In this paper we empirical testing the environmental kuznet curve hypothesis by analysis the relationship between environmental quality (Proxy carbon (VI) oxide ($CO_{2)}$ emission per capita) and per capita income. The panel estimation such as fixed effect and random effect were applied. From the results, the fixed effect model for $CO_2$ revealed that population density, per capita income, per capita income squared, trade openness, exchange rate(real effective exchange rate proxy), and agriculture were statistically significant. The negative coefficient indicated in the following variables-agriculture, exchange rate, and trade openness. Any percentage increases in those variables, reduces the Environmental quality (proxy $CO_2$) in selected West African countries. The results further indicated that trade openness lead to an increases in environmental pollution by improving key economic activities such as mining, which may reduce $CO_2$ per capita emission in the selected West Africa countries. For the population density has positive and significant effects on environmental quality and has the a-priori expectation in our model.*

**KEYWORDS:** environmental quality, co2 emission, per capita income, panel estimation, growth rate.

## INTRODUCTION

Natural resources, climate change variables and pollution affect the environmental quality and that turn out to affect the economics growth of the country over time. This affects the majors keys sectors of the country, the service, the manufacturing and most importantly the agricultural sectors of the country As agriculture is the backbone of the economics of most west African countries and its act as the cornerstone to development the environmental injustice causes by mostly human and nature causes the quality of life, standard of living and life expectancy to have negative impacts on growth in west Africa. It leads to high level of poverty, food insecurity of lack of rainfall and traditional ways of farming. The pollution causes by artificial means and deforestation, overgrazing, degradation, bushfire are causes more harm than good to artificial production. Natural resources intensity affect growth in Africa and that lead to lower sustainable development goals to

achieve in the Africa. We must fight together to remove or reduces this myth in west Africa by ways and means of adaptation and mitigation of climate impact to new ways and management of resources we have for the future inter-generation to enjoy life and property of west African countries.

For instance, environmental; quality attracts lots of researchers' to investigate the damages caused by environment and it relationships with growth in economy and standard of living of the peoples. Most papers found negative link between environmental injustice like pollution, land degradation, deforestation, climate changes variables, to impact negatively with economic growth. The looking for better and most environmental quality topic worldwide attracts attention. The research problems in Western African countries can be regarded their level of rainfall, temperature, $CO_2$, and renewable energy. However, this has impacted on their level of survival and negatively on the economics of West Africa countries. The study of the environment in West Africa is very important and paramount to society growth and development. The African poverty dynamics rises as climate problems rise on the environment. The innovative ways of climate control on agriculture, services and manufacturing will go a long ways to sustain the economy of West Africa. As population rises the growth rises, climate changes damages rises. So without proper tools for adoption and mitigation strategy, West African countries will be bound to have vulnerable to pollution, diseases, drought, poverty and starvation.

**What is Environmental Economics?**

The field that studies the financial impact of environmental policies. Environmental economists perform studies to determine the theoretical or empirical effects of environmental policies on the economy. The basic argument underpinning environmental economics is that there are environmental costs of economic growth that go unaccounted in the current market model. These negative externalities, like pollution and other kinds of environmental degradation, could then result in market failure. Environmental economists thus analyze the costs and benefits of specific economic policies, which also involves running theoretical tests or studies on possible economic consequences of environmental degradation. Environmental policies and procedures are key ways to deal with environmental mess and to implement the policies to control and apply the ways and manner to deal with climate change in Africa.

**What is Environmental Kuznet's Curve Hypothesis?**

Environment Kuznet curve hypothesis stated that as the environmental variables like pollution, degradation, deforestation, erosion, flooding, bushfire etc. These factors rises as the income per capita of the real GDP of the country reduces. The environmental Kuznets curve suggests that economic development initially leads to a deterioration in the environment, but after a certain level of economic growth, a society begins to improve its relationship with the environment and levels of environmental degradation reduces. This is called diminishing marginal utility of the environment. It can be increase, constant and decreases and even negative, and environment damages rises. In contrast, income level increases, then environmental damages decreases and

country growth rises. This mean that according to Kuznet curve environmental impact indicator is an inverted U-shaped functions of income per capita.

Environmental kuznet curve hypothesis was developed by Grossman and Krueger in early 1990s.The environmental strategy develop by UN called sustainable development, which comprises of zero hunger, environmental quality and so on. According to Omotolaibi (2009), greater economics activities eventually hurts the environment is usually based on static assumption that technology, environmental investment and taste, income rises, quality of improving the environment rises. The investment rises, improvement of environment rises (bidirectional relationship). Most of these studies can generate an inverted U-shape curve of pollution intensity, but there is no inevitability about this. The result depends on the assumptions made and the values of particular parameters. Lopez (1994) and Selden and Song (1995) assumed infinitely lived agents, exogenous technological changes, and that pollution is generated by production and not by consumption. John and Pecchenino (1994) and McConnell (1997) developed models based on overlapping generations where pollution is generated by consumption, rather than by production activities. It seems fairly easy to develop models that generate EKCs under appropriate assumptions, but none of these theoretical models has been empirically tested. Furthermore, if, in fact, the EKC for emissions is monotonic, as more recent evidence suggests, the ability of a model to produce an inverted U-shaped curve is not necessarily a desirable property.

**What is Sustainable Development?**

Sustainable development was explicitly popularized and contextualized by the Brundtland Commission in the document "Our Common Future" where it was defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (UN, 1987). The Brundtland Commission focused on three pillars of human well-being: economic, socio-political and ecological/environmental conditions. The basic concept endorses putting in place strong measures to spur economic and social development, particularly for people in developing countries, while ensuring that environmental integrity is sustained for future generations. The variables below I challenging sustainable development.

Agriculture is by far the thirstiest consumer of water globally, accounting for 70% of water withdrawals worldwide, although this figure varies considerably across countries. Rain-fed agriculture is the predominant agricultural production system around the world, and its current productivity is, on average, little more than half the potential obtainable under optimal agricultural management. By 2050, world agriculture will need to produce 60% more food globally, and 100% more in developing countries.

Industry and energy together account for 20% of water demand. More-developed countries have a much larger proportion of freshwater withdrawals for industry than less-developed countries, where agriculture dominates. Balancing the requirements of sustainability against the conventional view of industrial mass production creates a number of conundrums for industry. One of the

biggest is globalization and how to spread the benefits of industrialization worldwide and without unsustainable impacts on water and other natural resources.

Domestic sector accounts for 10% of total water use. And yet, worldwide, an estimated 748 million people remain without access to an improved source of water and 2.5 billion remain without access to improved sanitation.

More than half the world already lives in urban areas and by 2050, it is expected that more than two-thirds of the global population of 9 billion will be living in cities. Furthermore, most of this growth will happen in developing countries, which have limited capacity to deal with this rapid change, and the growth will also lead to increase in the number of people living in slums, which often have very poor living conditions, including inadequate water and sanitation facilities. Therefore, the development of water resources for economic growth, social equity and environmental sustainability will be closely linked with the sustainable development of cities.

Ecosystems. Perhaps the most important challenge to sustainable development to have arisen in the last decades is the unfolding global ecological crisis that is becoming a barrier to further human development. From an ecological perspective, the sustainable development efforts have not been successful. Global environmental degradation has reached a critical level with major ecosystems approaching thresholds that could trigger massive collapse. The growing understanding of global planetary boundaries, which must be respected to protect Earth's life support systems, needs to be the very basis of the future sustainable development framework.

**Literature Review**

The empirical evidence of the presence of EKC for environmental quality using econometrics tools. In this study we selected nine West African countries with similar characteristic. A study done by Daly (1997) stated that environmental degradation reduces human welfare. No Evidence of the existence of EKC was done by Olusegun (2009). Different scholars have different opinion. Using a time series and cross section for the OECD countries, Diskgraat and Vollebergh (1998) evidently that their existed for $CO_2$ emission in the individual OECD countries, but not the case of combined both at once. Using ARDL by Jalil and Mahmud (2009) found out that EKC had inverted U- shaped in china. A VECM was used by Lean and Smith (2010), found that existed of quadratic relationship between environmental quality and economic growth. Inverted U-shape was found by many scholars included and not limited on Kaika and Zervas (2011) and Sanglimsuwan (2011). There is still lots to be done on climate changes effects on growth through channeling under reviews, such as agriculture, manufacturing and industries, services sectors pollution, degradation, burning, bushfire. There is lots of limitation as before and now, new data sets new technology, new research, new impact of climate change on both animals and plants. The effect of rainfall on growth. Most researchers especially (Kaufmann *et al.,* 1998, Pauly 1998, Suri and Chapman 1998, all mention that inverted U-shaped between environmental quality and growth. However, some researchers added corruption and found no evidence for the existed of EKC. Some added population and found out that population rises, pollution rises and growth reduces (Dinda, 2004).

## METHODOLOGY

### Data Source and Sampling technique

This paper used the secondary data from World Bank from 1969-2017. The environmental quality was demonstrated to help us to assess the presence or non-presence of environmental kuznet curve hypothesis. As of different country fixed effect, we employed panel data set analysis. The sampling criteria is divided into two## region in West Africa, Francophone and Anglophone speaking countries. The assumption is that the nine West African countries included in this studied had similar income status, similar demographic status, similar environmental pollution status and degradation and finally similar market structure.

### Data Analysis

The study used panel data analysis. Panel data analysis can be given concise treatment using matrices. We used econometrics books for details for panel data, including Davidson and Mackinnon (1993), Greene (2000), Hayashi (2000) and Wooldridge (2010). As they put in this way, panel data is any data set that has both cross-sectional dimension and time-series dimension with the same cross-section units over time. The importance of panel data is that it helps us to control unobserved variables and variables that change overtime but not across entities (e.g cultural factors or difference in business practices across entities, national policies, law and regulation, international agreement, environmental differences etc).Though it is also has drawbacks are sampling design, macro panels or cross country dependency non-response and macro panels, correlation between countries.

By doing panel data estimation we first explored the present of stationary process in our data. By doing so we used co-integration testing.

Co-integration Testing (Engle and Granger, 1987)

The notion of co-integration applied when two series are I(1), but a linear combination of one on the other is not spurious, but instead tell us something about the long run relationship between them (Wooldridge page 632). For the short term dynamics, co-integration between two series also applies a particular kind of model (Wooldridge page 632).The co-integration equation given below:

If we have two I (1) processes, $y_t$ and $x_t$ , there is a coefficient $\beta$ such that $y_t - \beta x_t$ is an I(0) process, which is always stationary. It means y and x are stationary or co-integrated and coefficient $\beta$, is co-integrated parameter.

$S_t = y_t - \beta x_t$ …….. (1)

If we know $\beta$ above in equation one, to test for co-integration will be regress$S_t$ $on$ $y_t$ $x_t$. We will do DF test for cointegration in equation below: $y_t - \beta h_t$ is I (0).

$S_t = y_t - \beta x_t = (\delta - \beta\mu)t + (g_t - \beta h_t)$ , which is trend stationary process.

According to Wooldridge for co-integration requires that there not be a trend , which means $\delta = \beta\mu$ for I(1) process with drift, it is possible that the stochastic parts that is $g_t$ and $h_t$ above are co-integrated, but the parameter $\beta$, that causes $g_t - \beta h_t$ to be I(0) does not eliminate the linear trend.

Theoretical Model

The panel data models like this

$y_{it} = \beta_0 + \beta_1 x_{it1} + \beta_2 x_{it2} + \beta_3 x_{it3} + \beta_4 x_{it4} + , , , , , , , + \beta_k x_{itk} + u_{it}$ ……(2)

$y_{it} = \beta_0 + \sum_{i=1}^{n} \beta_1 x_{itn} + u_{it}$ ……..(3)

A panel data method has two dimension, one is time series dimension and the other is croiss-sectional dimension. The panel data gives two most error components model as below:

$\backslash u_{it} = e_t + v_i + \varepsilon_{it}$……..(4)

The $u_{it}$ , the error term contains shocks that is the $e_t$ that affects all observations for all t periods, $v_i$ is city dependent, it affects all observation for cross-sectional unit for individual city for all I, and $\varepsilon_{it}$ for all I and t. The two components of panel data to deal with in this paper are; fixed and random effect model.

The framework for this panel technique study was developed by Russell Davidson and James G. Mackinon, (1999) and can be re-rewritten as follows:

$Y = X\beta + D\eta + \varepsilon$ ……(5), $E(\varepsilon\varepsilon)^T = \sigma^2 I_n$

The conditions for this paper on quality of environment on growth are that;
$Cov\ (\varepsilon\ , CO2, Combustible\ renewable\ energy) = 0, \forall\ RE$
$Cov\ (\varepsilon\ , CO2, Combustible\ renewable\ energy) \neq 0, \forall\ FE$

The first assumption above is that unobserved fixed effect or error term is uncorrelated for the random effect model (RE) and correlated with fixed effect model (FE). From above equations, according to Russell Y and $\varepsilon$ are n-vectors of elements $y_{it}$ and $\varepsilon_{it}$ for $\varepsilon$ and D is an n × m matrix of dummy variables, where; i=1, …..,,,, m, t=1,….,,,,T for the matrix raw and column J=1,…..,,,,,,,m. If row i=colum j i.e i=j.The $\beta$ denoted the coefficients or elasticity of $x_{i1t}, x_{i2t}, x_{i3t}, x_{i4t}, x_{i5t}, \ldots\ldots\ldots, x_{itk}$ is a k-dimensional vector of $Xs'$ and included the constant

term and $\varepsilon$, which is $\varepsilon_{it}$ is assume to be normal and iid with mean zero and $\sigma^2 I_n$ i.e. (0,1)=(0, $\sigma^2 I_n$)(Rossell, 1999).

Further, in order to make a clear conclusion whether we should choose between FE and RE. The only method that lead to that is Hausman test. The hausman test is where the null hypothesis is that the preferred model is random effects in which the covariance between the error terms at time period t is uncorrelated with the error term i.e. $Co\ (\varepsilon, Xs') = 0$. The alternative hypothesis which is fixed in which all the explanatory variables are correlated with the error term i.e. $Co\ (\varepsilon, X) \neq 0$.

How to perform Hausman Test

Step1: Run fixed effects model and store the estimates

Step2: Run Random effect model and store the estimates

Step3: Run Hausman Fixed Random.

If the null hypothesis is rejected, it means fixed effect is more appropriate for the analysis than the random effect estimation (Gujarat 2004).

**Empirical Model**

To assess the presence of environmental Kuznet Curve Hypothesis, the study adopted the model as follows:

$$\text{Ln}\, EQ_{it} = \beta_0 + \beta_1\ \text{LnPer}_{it} + \beta_2\ \text{Lnpden}_{it} + \beta_3 \ln \text{LnTO}_{it} + \beta_4\ \text{LnEx}_{it} + \beta_5\ \text{LnA}r_{it} + \beta_6 \text{psq} + v_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

The variables above abbreviated below.

gen LnEQ=log($CO_2$ emissionskgper2010USof)

gen LnG=log(GDP)

gen LnPer=log(GDPper)

gen psq=LnPer^2

gen LnA=log (Agri)

gen Lnpden=log (Populationden)

gen LnEx=log(OfEX)

gen LnTO=log(TradeOpeness)

The variables of this paper are logarithmized to allow the coefficients to be interpreted as rate of change of variables in elasticity form. $\ln EQ_{it}$ $(CO2)$ is the natual logarithm of environmental quality at time t and individual i , $\text{LnPer}_{it}$, is the natural logarithm of per capita income of the selected west African countries, $\text{Lnpden}_{it}$ is the population density in natural logarithm form, openness is also in log form, $\text{LnEx}_{it}$ is exchange rate is also in log form and we also square per capital income with logarimized it. All at time t and individual i.

The pooled ols estimator that is based on time demeaned variables is called fixed effect estimator or within estimator. The $v_{it}$ $and$ $\varepsilon_{it}$ are unobserved country fixed effect and the error term in the model respectively.Fixed effect estimation, pooled ols that has time demeaned variables is called fixed effect estimator(Wooldridge, 2013).

The relationship between GDP Per capita and GDP per capita squared on the Environmental quality ($CO_2$ emissions as a prox) is the turning point to obtain the Environmental Kuznets Curve. The simple relationship we would test is as follows:

$$\text{Ln}\, EQ_{it} = \text{a} + \beta_1 \ \text{LnPer}_{it} + \beta_2 Ln\text{psq} + v_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where: $\text{LnPer}_{it}$=log of the GDP per capita

LnPsq=log of the GDP per capita Square

Understanding the existence of environmental kuznet curve in our model, we first take the derivatives of environmental quality ($CO_2$ as a proxy) with respect to per capita income and we equate to zero. Therefore, to calculate the turning point of EKC= (-coefficient of the linear term/(2*coefficient of the squared term)).It means that the coefficient of the per capita income divided by two times the coefficient of per capita income squared. After this calculations, we would check whether the resulting value falls within the range of -gdp per capita or not. Thus, EKC exist at a point in which, $\beta_1 > 0, coefficient\ for\ GDP\ per\ capita\ and\ \beta_6 < 0, coefficient\ for\ GDP\ per\ capita$ Squared. In order word the marginal propensity of GDP per capita and GDP per caital squared are negative and positive respectively.

The present study followed Loom, Canning and Secilla (2004) and Afzal, Farooq, D.T Adu , E.K. Denkyirah (2010).We added agriculture as a variable to see whether it influenza the existing of the environmental quality on growth of the 13 selected west African countries with similar income status. According to (Dinda, 2004, Jorgenson and Clark, 2013), population increases, $CO_2$ emission as pollution level rises. GDP per capita square had negative sign and positive sign for official exchange rate on environmental quality(Proxy $CO_2$) according to (Morancho, and Moreales-hage, 2000 and Shi 2003) Trade openness i.e. export plus import divided by GDP impact negatively of growth (Iwatu, Okade, and Samreth, 2010 and Lucena 2005).

## RESULTS AND DISCUSSION OF FINDING

### Data and Descriptive Statistics

A brief descriptive of the data, the name of the variables, data sources and comment used in this study are presented in the table 1 below:

Table 1: Data Sources

| Name of Variable | Source | Comment |
|---|---|---|
| GDP Current(US$) | WDI | Current GDP $ |
| $CO_2$ Emission(EQ Proxy) | WDI | $CO_2$ emissions $ |
| Agriculture | WDI | Agriculture value added of $ |
| GDP per capita | WDI | GDP per capita $ |
| GDP per capita squared | WDI | GDP per capita square $ |
| Real effect exchange rate | WDI | Real Effect exchange rate |
| Trade Openness | WDI | Total Average Rainfall |
| Population density | WDI | Total Climate change Variable |

Note: WDI is World Development Indicator.

### Descriptive Statistics

Table 2: Descriptive Statistics

| Variables | Observation | Mean | Standard Deviation |
|---|---|---|---|
| LnEQ | 597 | -1.240327 | 0.4868291 |
| LnG | 649 | 21.71916 | 1.681393 |
| LnPer | 649 | 6.025311 | 0.7129649 |
| LnA | 633 | 3.443186 | 0 .3353611 |
| Lnpden | 650 | 3.496781 | 1.193989 |
| Psq | 649 | 36.81191 | 8.721851 |
| LnTO | 644 | -17.69584 | 1.796891 |
| LnEx | 649 | 4.321505 | 3.165415 |

| |
|---|
| LnEx =Growth rate of exchange rate |
| LnTO = Growth rate of trade openness |
| LnA= Growth rate of Agricultural sector |
| LnEQ = Growth rate of Environmental quality |
| LnG = Growth rate of GDP |
| LnPer=Growth rate of per capita income |
| Lnpden=Growth rate of population density |
| Psq=growth rate of per capita income squared. |

Sources: Authors' Computation by using Stata 13 for Window.

From Table 2. The descriptive statistic of this paper indicated that the years has gaps. That make the number of observation to fluctuate overtime. We used panel estimation for 13 West African Countries with similar $CO_2$ emission per capita and with similar income status. We logarithmized the variables to interpret as elasticity or rate of change of variables. The descriptive statistic which contains the mean, the standard deviation, the maximum and the minimum for the selected West African Countries. The rate of change of quality of environment (proxy $CO_2$ emission per capita $) has negative mean and negative volatility of (1.24) and (0.49) respectively. The growth rate of openness has lowest mean of -17.7. The growth rate of per capita is 6.03 closer to the mean of growth rate of population density and growth rate of agriculture combined. The turning point in which there is environmental kuznet curve hypothesis exist, the squared of the environmental quality has standard deviation of 8.7.

**Correlation**

Table 3. Correlation

| Variables | LnEQ | LnG | LnPer | LnA | LnTO | LnEx |
|---|---|---|---|---|---|---|
| LnG | 0.1009 | - | | | | |
| LnPer | 0.4196 | 0.7612 | - | | | |
| LnA | -0.3879 | -0.432 | -0.6156 | - | | |
| psq | 0.4021 | 0.7677 | 0.9969 | -0.620 | -0.6617 | 0.0096 |
| LnTO | 0.0105 | -0.9690 | -0.6518 | 0.3366 | - | |
| LnEx | -0.2109 | -0.0002 | 0.0037 | -0.078 | 0.0374 | - |

Source: Authors' Computation by using stata 13 for Window.

From Table 3 above. The correlation is the relationship between variables under study. The growth rate of GDP and the growth rate of environmental quality has positive correlation of 10%. As $CO_2$ emission per capita rises, the rate of growth of GDP in the selected West African countries with similar income status also increases. The growth rate of agriculture has negative impacts on the growth rate of $CO_2$ per capita emission, on growth rate of GDP and growth rate of per capita income. This is due to the fact that in West African countries lower agriculture is due to lower rainfall. The exchange rate and trade openness has negative correlation with $CO_2$ emission per capita. The per capita income and per capita income squared has positive correlation with environmental quality. Meaning, in selected West African countries, the rate of growth of their income is due to quality of environment free from deforestation, pollution, erosion, drought etc. It is due to high rainfall, quality of environment, high $CO_2$ emission per capita, and reforestation will lead to positive correlation with the environment up to close to 42% and 40% respectively. The growth rate of GDP is due to inversely relationship with the growth rate of agriculture, growth rate of exchange rate and growth rate of trade openness. In the West African countries selected, growth of agriculture has negative impacts with the following variables; environmental quality, growth of

GDP and growth of per capita income. This is revealed that in West African countries should do more on climate change mitigation and adaptation that hindrance the growth of agriculture.

**Panel Unit root Test**

Table4: Panel Unit Root test (Fish Test in the first Difference)

| Variables | T-Ratios | | P-Value | |
|---|---|---|---|---|
| | Drift | Trend | Drift | Trend |
| LnEQ | -10.8544 | -4.3755 | 0.0000*** | 0.0000*** |
| LnPer | -5.7913 | 1.4098 | 0.0000*** | 0.0815* |
| LnG | -3.5710 | -1.2007 | 0.0003*** | 0.1170 |
| LnA | -8.3394 | -2.5065 | 0.0000*** | 0.0073** |
| Lnpden | -4.2561 | -23.1199 | 0.0000*** | 0.0000*** |
| LnTO | -3.7190 | -2.3539 | 0.0002*** | 0.0107* |
| Psq | -4.8720 | -0.7478 | 0.0000*** | 0.2286 |
| LnEx | -3.6441 | -0.7281 | 0.0003*** | 0.2345 |

*Notes:* * , ** and *** denote significance at 10%, 5% and 1% respectively.

Sources: Authors' Computation by using Stata 13 for Window.

The study covered from 1969-2016, with thirteen West African countries having similar income status. The questions that arises for panel unit root test –fisher type unit root test for the coefficients based on the augmented dickey –fuller tests. Does our data contains a unit root? How do we know the confidence level at which we can reject the null hypothesis or accept the alternative vice versa. For the growth rate of GDP is that all panel does not contain a unit root. Given our results we failed to reject the null hypothesis. Since all the values in this test for growth rate of GDP are greater than 1%, 5% and 10%, we failed to test the null of exist the unit root. This means there are unit root in our panels under the given test condition (Included panel time trend and mean).This also answer the second question, because the p-value tell us at which level of significance to reject or accept the null hypothesis. The table 4. Above contains all the variables with corresponding t-ratios and p-value with drift and trend. Only the intercept of the growth rate of GDP is statistically significant.

**Estimation of Environmental Kuznet Curve Hypothesis for $CO_2$**

The results of econometric estimation is to identify whether growth rate of $CO_2$ emission per capita (proxy environmental quality) is existed for EKC in 13 selected West African countries with similar income status presented in table----The hausman test indicated that the used of random effect is more appropriate when we used the effect of environmental quality on growth rate of per capita income and growth rate of per capita income squared. This was not the case when we regressed growth rate of EQ on the variables included per capita income and squared. According to hausman test-chi-squared statistic, the used of fixed effect is more appropriate for our analysis.

**Fixed Effect Model**

The fixed effect model for $CO_2$ revealed that population density, per capita income , per capita income squared, trade openness, exchange rate(real effective exchange rate proxy), agriculture, were statistically significant. The negative coefficient indicated in the following variables-agriculture, exchange rate, and trade openness. Any percentage increases in those variables, reduces the Environmental quality (proxy $CO_2$) in selected West African countries. Only trade openness is not statistically significant associated with positive coefficient. The results further indicated that trade openness lead to an increases in environmental pollution by improving key economic activities such as mining, which may reduce $CO_2$ per capita emission in the selected West Africa countries. Sharma (2011), Akin (2014) revealed in their papers that trade openness leads to environmental pollution in developing countries. This in turn leads to highest $CO_2$ emission per capita in the environment and that can leads to lower life expectancy. According to our result GDP per capita and GDP per capita squared are all statistically significant at 1%, 5% and 10% and per capita income squared associated with negative sign. The GDP per capita is significant and positive. This is true because the EKC exist at a turning point in which $\beta_1 > 0 \; and \; \beta_6 < 0$ i.e per capita income and per capita income squared respectively.This results was supported by Adu and Denkyirah (2017), Dijkgraat and Vollebergh (1998) revealed in their studied that GDP per capita has significant and positive impacts on $CO_2$ emission per capita. Official exchange rate (proxy real effective exchange rate) has statistically significant and associated with negative sign. A percentage increases in exchange rate in these countries, $CO_2$ emission per capita reduces by 4.8%.This may be due to the fact that we selected more countries in our study than them. This implying that appreciation of the local currency against the major currency decreases at the level of $CO_2$ emission per capita. Our analysis indicated that exchange rate improvement for our domestic currency can lead to reduction in $CO_2$ emission per capita. We added agriculture as the predicted backbone of West African countries. Growth rate of agriculture has negative and statistically significant effect on environmental quality. An increases can lead to substantially reduction of 25.6% of $CO_2$ emission per capita. For the population density has positive and significant effects on environmental quality and has the a-priori expectation in our model. It means that as population increases, $CO_2$ emission rises approximately 34.64% in the selected West African countries. In addition, population rises can lead to improve people life, but cautious must be taken into account for quality of environment.

Table 5: Fixed effect Model

| Variable | Equation 1(LnEQ) | | R-sq.=25%<br>Number of observation=584<br>Hausman prob. Chi-squ=0.0431<br>F(12, 565)=40.58 |
|---|---|---|---|
| | t-ratio<br>Std E | P-value<br>Coef | |
| Constant | -5.27<br>(0.79) | 0.000***<br>-4.17 | Standard errors between parentheses,* p=0.10, ** p=0.05, *** p=0.01<br>Sources: Author Computation By using stata 13 for window |
| LnPer | 4.46<br>(0.22) | 0.000***<br>0.998 | |
| LnA | -3.78<br>(0.07) | 0.000***<br>-0.26 | |
| Lnpden | 4.84<br>(0.07) | 0.000***<br>0.35 | |
| LnTO | 0.41<br>(0.04) | 0.684<br>0.02 | |
| psq | -4.21<br>(0.018) | 0.000***<br>-0.08 | |
| LnEx | -4.94<br>(0.009) | 0.000***<br>-0.05 | |

Random Effect Model Results

The random effect model for $CO_2$ on growth rate of per capita and growth rate of per capita squared. We found out that both per capita squared and per capita are statistically significant and negative and positive sign respectively. This may be due to the fact that the first derivative with respect to EQ is negative. Even the intercept term, if all the variables become zero, EQ is statistically significant and negative sign. Without the other variables, the $CO_2$ emission in West African countries will be negative autonomous according to the result generated.

Table 6: Random effect Model

| Variable | Model (LnEQ) | | |
|---|---|---|---|
| Depedent variable LnA | z-ratio<br>Std E | P-value<br>Coef | Hausman chi-0.3320<br>R-squared=36%<br>Number of observation=597 |
| Constant | -8.59<br>(0.68) | 0.000***<br>-5.84 | Standard errors between parentheses,* p=0.10, ** p=0.05, *** p=0.01<br>Sources: Author Computation By using stata 13 for window. |
| LnPer | 5.99<br>(0.22) | 0.000***<br>1.345 | |
| psq | -5.09<br>(0.019) | 0.000***<br>-0.095 | |

## CONCLUSION AND POLICY RECOMMENDATION

The turning point estimation technique was used to determine at which rate the environmental kuznet curve hypothesis exist. It exist at a point in which the coefficient of per capita income and the coefficient of per capita income square become positive and negative respectively. The fixed effect model for $CO_2$ revealed that population density, per capita income , per capita income squared, trade openness, exchange rate(real effective exchange rate proxy), agriculture, were statistically significant. The results further indicated that trade openness lead to an increases in environmental pollution by improving key economic activities such as mining, which may reduce $CO_2$ per capita emission in the selected West Africa countries. Sharma (2011), Akin (2014) revealed in their papers that trade openness leads to environmental pollution in developing countries. The results found out that, the GDP per capita is significant and positive. This is true because the EKC exist at a turning point in which $\beta_1 > 0 \; and \; \beta_6 < 0$ i.e per capita income and per capita income squared respectively.This results was supported by Adu and Denkyirah (2017), Dijkgraat and Vollebergh (1998) revealed in their studied that GDP per capita has significant and positive impacts on $CO_2$ emission per capital.

The policy recommendation is that the government of the country and its respective municipality should take account the following measures; replace disposable items with re-usable, pass on paper, conserve water and electricity, reduces plastic and paper waste, support local and environmental friendly to enable cost effectiveness, recycling materials that are waste product that will reduces pollution, save animals and plants, cut down consumption of energy and slow down global warming and finally, the government can steps forward to make more aware of the needs of the environment and climate change effect it leads to.

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