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An Application of Quantile Regression on the Relationship between Economic Growth and the Quality of Environment in Selected African Countries

Aminu Hassan Jakada[a,*], Suraya Mahmood[b]

a. Department of Economics and Development Studies, Federal University Dutse, Jigawa State Nigeria, Nigeria.
b. Faculty of Business and Management, Universiti Sultan Zainal Abidin, Terengganu, Malaysia.
* Corresponding Author, E-mail: aminu.jakada@fud.edu.ng

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ABSTRACT

This study examined the determinants factors of environmental quality by employing a panel quantile regression to incorporate the effects of economic growth on the quality of environment and ascertain the validity of EKC hypothesis within the research background of seven leading African economies over the period 1970 to 2019. The advantage of this method is considering the distributional heterogeneity to provide a detailed description of linkage between the CO2 emissions and driving factors at different emissions levels. The results show that the effects of determinants on CO2 emissions are heterogeneous. Besides, the quantile regression estimate describes the economic growth influence on CO2 emissions to be positive and higher at the 50th quantile than in other classes of quantiles. The square of economic growth tend to have insignificant effect on the 10^{th} and 25^{th} quantile but effect is negative and significant on the 50^{th} , 75^{th} and 90^{th} quantile. This justify the presence of EKC hypothesis on the 50^{th}, 75^{th} and 90^{th} quantile. The empirical results of the study reveal that the EKC hypothesis is supported in these leading African economies. Consequently, policymakers should centre on the heterogeneous effects of driving forces on CO2 emissions in different quantiles during the process of carbon emission reductions.

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1. Introduction

The most challenging and debated issue of environment that attracted the policymakers attention recently is global warming (Acheampong, 2018). The escalation of carbon emissions as well as the absorption of GHGs (Green House Gases) within the atmosphere that leads to global warming is associated with implication that is severe for both human and economic development. Emissions of carbon dioxide is the leading source of GHGs that leads global warming (Acheampong, 2019). Based on the studies undertaken by many researchers, emissions of carbon dioxide is recognized as the major source of pollution and leads to high rate of death in developing economies (Ssali et al., 2019).

It contributed greatly to cardiovascular as well as respiratory illness. Statistics from the WHO (World Health Organization) revealed that air pollution account for 7,000,000 lives on annual basis (WHO, 2018). The escalation of temperature result in to a series of adverse consequences, such as rising level of sea, the ozone layer damage as well as the regular incidences of dangerous weather event (Silva and Kawasaki, 2018). All these tend to have negative effect on the stability of the ecosystem of the earth as well threaten the survival of human (Xu et al., 2017).

In 2015, 196 nations supported and joined the United Nations Framework Convention on Climate Change (UNFCCC) due to the urgent need to keep the environment habitable for humankind. Since 1995, countries that support the UNFCCC have held a series of meetings to discuss the activities that must be taken to reduce global warming. The Kyoto Protocol, which was signed in 1997, was one of the significant outcomes of their sessions. The protocol established legally enforceable responsibilities to cut emissions, particularly for advanced countries. As good as it appears, this deal was never meant to be a worldwide accord because it was primarily focused on the European Union and a few other industrialized nations, leaving out major polluters such as the United States, India, and Canada, which declined to ratify it. Following that, more than 194 UNFCCC parties signed the Paris Agreement in December 2015, pledging to keep GHG emissions well below 2 degrees Celsius by 2100. With each passing day leading up to the United States' exit from the pact (on June 1, 2017), this is becoming increasingly questionable. The US alleged that the agreement benefits other countries at the expense of the US. Whatever way the coin falls, the Paris Agreement was a watershed moment, and rigorous adherence to it is essential for environmental sustainability. With this achievement, worldwide collaboration on environmental preservation has entered a new age (Bloomberg and Pope, 2017; Zhang et al., 2017).

Biodiversity conservation is critical for human survival as well as long-term growth and development. As a result, several investigations on the relationship between chosen macroeconomic factors and CO2 emissions have been performed for over two decades (see Ozatac et al., 2017; Destek and Sarkodie, 2019; Jamel and Derbali, 2016; Ozatac et al., 2017; Kahia et al., 2017; Green and Stern, 2017). While some specifically explored growth and CO2 emissions nexus in Africa (Asongu et al., 2016; Esso and Keho, 2016; Hamilton and Kelly, 2017; Kais and Ben Mbarek, 2017; Saidi and Hammami, 2015). Global warming, mostly driven by carbon emissions, has made life appear to be more difficult for humans. (Bong et al., 2017; Lv and Xu, 2019). It contributes to global warming. This shift is a worldwide issue. This is not just a problem in developed countries (Ito, 2017). Climate change's dreadful consequences have been a major issue for the world. If CO2 emissions to be reduced, a thorough understanding of their main causes is essential (Dong et al., 2019; Sarkodie and Strezov, 2019).

Against this backdrop, numerous research studies have been dedicated to the determinants of emissions both in a single country case (Cansino et al., 2016; Chin et al., 2018; Mrabet and Alsamara, 2017; Raggad, 2018) and for a group of countries (Balogh and Jámbor, 2017; Dogan and Seker, 2016; Lin et al., 2017; Shuai et al., 2017; Yeh and Liao, 2017). In spite of the concentrated efforts to lessen the absorption of carbon dioxide emissions on the earth, globally carbon emissions have been rising. According to IEA (International Energy Agency) (2019) report in the year 2018, energy-related global carbon emissions escalate by 1.7%, this reveals an outright upsurge of 560 million tons to a long-period high of 33.1 Gt (Gigatons) after staying regular over the past four consecutive years. The region of Africa not be an exception acknowledge an escalation of carbon dioxide emissions form 884.53 million tons in year 2000 to around 1.19 billion tons in the year 2010 as well from 1.23 billion tons in the year 2012 to 1.29 billion tons in 2015 and the amount escalates to 1.33 billion tons in 2017 (WDI, 2019). Similarly, the GDP growth rate of the region average of 2.2% between 2015 and 2017 (Wang and Dong, 2019). The concomitant upward surge in economic growth will possibly subject the region to a severe environmental problem especially in terms of CO2 emissions.

This excessive increase in the amount of carbon emissions both at global and regional level contradict with climate change Paris Agreement of reducing the amount of carbon emissions (Acheampong and Boateng, 2019). The report of IEA (2018) put forward that the escalation in carbon emissions across the globe is due to robust economic growth experienced globally, weak effort in efficient use of energy as well as the lower price of fossil fuel. The activities of Macroeconomic variables discharge large amount of carbon dioxide emissions that leads to its concentration rate in the atmosphere (EPA, 2017). Likewise, carbon emissions influence on the global warming is anticipated to carry on in the future (Cosmas et al., 2019). The activities of Macroeconomic variables discharge large amount of carbon dioxide emissions that leads to its concentration rate in the atmosphere (EPA, 2017). Likewise, carbon emissions influence on the global warming is anticipated to carry on in the future (Cosmas et al., 2019). This was one of the motivating factors for this study. Whether the quality of the environment has also truncated growth in the region, was another motivation for the study.

As against the background, the purpose of this study is to contribute to the prevailing literature by analyzing the effect of economic growth on the quality of environment and at the same time ascertain the validity of the EKC hypothesis in six leading African countries over the period of 1970 to 2019 respectively. Unlike the previous studies that use the traditional OLS estimations in determining the quality of environment in Africa, the current study estimated the determinant factors of environmental quality by providing evidence from the model of quantile regressions. In comparison with traditional estimation of OLS, quantile regression not only serve as an improvement of the model robustness, but also disclose essential information on the tail of the distribution of the data as well obtain a clear portrait of the sample data, particularly for a data that is not normally distributed. Precisely, this research focuses predominantly on three essential issues. First, why the current study decide on the model of quantile regression to examine the effect of economic growth on the quality of environment in Africa? Second, how these determinants factors influence the quality of environment under different categories of quantile? Third, at what point of quantile does the EKC hypothesis is presence in these leading African countries?

The remaining aspect of the article are structured as follows. Section two reviews the related literature as well as prior studies. Section three pronounce the methodology as well as the sample of the data. Section four presents and deliberates the empirical outcomes. Section five delivers the conclusion as well as the policy implications.

2. Literature Review

It is vital for a meaningful research to undertake a review of prior empirical researches that are related to the subject matter of the research. Henceforth, the current research review related literature for the purpose of exploring the issues that had been discussed and methods of analysis used. This assists to establish limitations and contributions while examining the relationship that exist between economic growth, financial development and foreign direct investment with the quality of environment.

Economic growth is claimed to be one of the major factor behind the tenacious escalation of carbon emissions in particular and global warming in general (Acheampong and Boateng, 2019). The association between carbon emissions and economic growth have examined widely. Some studies are of the opinion that economic growth leads to degradation of the environment through the escalation of the level of carbon dioxide emissions (Al-Mulali et al., 2015; Alam et al., 2016; Amri, 2018; Begum et al., 2015) while other categories of studies are on the view that economic growth is obligatory to enhance the quality of the environment (Aye and Edoja, 2017; Ma and Jiang, 2019; Sung et al., 2017; Yeh and Liao, 2017; Zhu et al., 2016). Most of the literatures on the connection between carbon emissions and economic growth is originated in the hypothesis of EKC (Environmental Kuznet Curve). The hypothesis of EKC assumes that an inverted form of U-shaped connection occur amid the carbon emissions and economic growth. Henceforth, at the early level of economic growth, emissions of carbon dioxide increase, then again away from a certain level of economic growth, emissions of carbon dioxide decline (Grossman and Krueger, 1991; Grossman and Krueger, 1995; Stern, 2004). Empirical results from the previous studies on the effect of economic growth on carbon dioxide emissions remain greatly inconsistent. For example, Ahmad et al. (2017) examined the relationship between carbon emissions and economic growth in the case of Croatia through the use of ARDL techniques of analysis and the outcome of the study show that inverted form of U-shaped connection between economic growth and carbon emissions exist in the long run and this is in supports of the hypothesis of EKC.

In the case of the economies of Asia et al. (2015) used the GMM to study the relationship carbon emissions and economic growth. The findings support the hypothesis of EKC validity. In the same vein, Heidari et al. (2015) applied the econometrics techniques model of Panel Smooth Transition Regression (PSTR) and investigate the relationship between economic growth and the quality of environment. The result of the study indicates an overturned U-shaped connections between carbon emissions and economic growth, this confirm the presence of EKC. However, Begum et al. (2015) examines the dynamic effects of GDP growth, growth of population, consumption of energy on carbon emissions in Malaysia over the period of 1970 to 2009. The study uses the techniques of Dynamic Ordinary Least Square (DOLS) as well as the test of Sasabuchi–Lind–Mehlum U (SLM U). Accordingly the findings of the study rejects the EKC hypothesis.

Similarly, another study examines the link between carbon emissions and income within the EKC context by applying two forms of empirical models for a sample of 26 high income countries of OECD and 52 emerging economies over the period of 1980 to 2010. Özokcu and Özdemir (2017) employed the panel techniques of estimation with Driscoll-Kraay Standard Errors Application. The estimated result reveals that an increase in income leads to a rise in carbon emissions in both of the models. Consequently, the results of the study are not in supports of the hypothesis of EKC. Henceforth, in investigating the association between carbon emissions total factor productivity as a proxy for income, trade, information and communication technology (ICT), energy consumption and financial development in Tunisia over the period of 1975 to 2014. Amri (2018) applied the ARDL techniques of analysis with the method of break point. The result of the study shows that the EKC hypothesis is not present in Tunisia. It indicates that the economy has not achieved the demanded level of the aggregate factor productivity to confirm the hypothesis of EKC.

Destek et al. (2018) looked at the EKC for environmental impact in 15 EU countries from 1980 to 2013. The authors claimed that the ecological footprint was a far more comprehensive and accurate indication of environmental deterioration than carbon dioxide emissions. The authors used the group-mean FMOLS, group-mean DOLS, and the dynamic common correlated effect (DCCE) estimators to look at the impact of renewable energy consumption, trade openness, and non-renewable consumption on the environment after establishing cointegration between the regression variables. The study discovered that the coefficient of real income on the ecological footprint is negative, while the coefficient of the square of real income is positive, resulting in a "U"-shaped connection, refuting the EKC hypothesis. To this end, Altintaş and Kassouri (2020) used the interactive fixed effect, dynamic common correlated effects, and a heterogeneous panel model in a recent study to evaluate the validity of the EKC hypothesis for 14 EU countries from 1990 to 2014. The authors investigated the true driving force behind the EKC and discovered that the EKC for Europe was linked to per capita ecological footprints rather than per capita carbon dioxide emissions, with a one-way causality going from economic growth to per capita ecological footprints.

Based on the reviewed studies, it is witnessed that several studies have investigated the relationship between economic growth and the quality of environment. However, previous studies used techniques of estimation that support OLS assumptions of normality distribution that is hardly found in panel data to overcome this problem and also provide hidden information on the tail of data that are not distributed normally, the current study make methodological contribution through the use of quantile regressions techniques of analysis as were used by few of the previous studies. In addition most of the previous studies that consider economic growth on the quality of environment concentrate on developed and industrialized countries with few of the researches on developing countries, especially Africa. Therefore, examining the effect of economic growth on the quality of environment in relation to Africa will add to the prevailing literature on the studies of environment.

3. Methodology and Model Specification

3.1 Quantile Regression Model

The method of quantile regressions was first made onward by Koenker & Bassett (1978). Based on the points of quantile, this techniques can hold all the substantial advantages of the sample data to undertake analysis of regression. Therefore, quantile regressions would undertake conditional estimation of quantile in which each particular function pronounce behavior of each particular points in the conditional form of distribution. The theoretic content of the model of panel data are as follows:

$$Y_i = X_i'\rho_\varphi + \pi_{\varphi i}, 0 < \varphi < 1 \quad (1)$$

$$Quant_\varphi(Y_i/X_i) = X_i\rho_\varphi \quad (2)$$

Where Y represents the explained variable while X stands as the vector of the explanatory series, π is the stochastic error term that have a conditional distribution of quantile is the same as zero. Hence $Quant_\varphi(Y_i/X_i)$ signifies that φ^{th} quantile for Y that is the explained variable. The approach of quantile regression give room for the determination of the effect of covariate across diverse location in the dependent variable distribution.

The φ^{th} estimator of the quantile regressions is $\hat{\rho}_\varphi$ that serve as the solution for the following equation:

$$min\sum_{Y_i>X_i'\rho}\varphi|Y_i - X_i'\rho| + \sum_{Y_i> X_i'\rho}(1-\varphi)|Y_i - X_i'| \quad (3)$$

The overhead equation acquires the solution through the linear programming. The regression of the median is quantile regression special case and is generated through the assumption that $\phi = 0.5$ respectively. The different quantiles can be obtain by setting the different values of the ϕ as revealed in equation three. Henceforth, for the purpose of expressing the relationship that tends to exist between the independent variables as well as the different form of conditional distribution of the dependent variable, the study set 10^{th}, 25^{th}, 50^{th}, 75^{th}, as well as the 90^{th} different classes of quantiles. The study can make use of bootstrap technique suggested by Buchinsky (1995) to generate in the quantile regression the parameter's standard deviation. The regression of quantile is one of the essential technique of estimation use because of its robustness as well as consistency particularly when the stochastic error term contained heteroscedasticity as well is not distributed normally.

3.2 Model Specification and Data Source

The study is aim at examining the connection between economic growth and the quality of environment as well as ascertaining the validity of EKC hypothesis within the model of EKC. The model of EKC reveals the different environmental quality parameters in relations to changes in income. It suggested that at the earlier phases of economic growth, related issues of pollution, and natural resources degradation are likely to take place. This process will proceed until when a particular level of per-capita income is reached and then the process proceed in a reversible way that is higher income cause enhancement of the quality of environment. Following the work of Charfeddine & Khediri (2015) and Hanif (2018) applied the following functional form of EKC equation:

$$lnCO_2 = f(Y, Y^2, Z) \quad (4)$$

where $lnCO_2$ stands as the carbon dioxide emissions that measure the quality of the environment as the explained variable and Y, Y^2 as well as Z represents the GDP per capita as the measure of economic growth, the square of GDP per capita stands as the proxy for the square of economic growth while Z represents the other determinants factors of environmental quality that are not captured in the EKC model respectively. Subsequently the model of EKC curve would be extended to include other factors that determine the quality of environment such as financial development as well as foreign direct investment as well as the model is turn into functional form of econometrics model that is identified as follows:

$$lnCO_{2it} = \beta_{it} + \beta_2 GDP_{it} + \beta_3 GDP_{it}^2 + \beta_3 FDI_{it} + \beta_4 FD_{it} + \mu_{it} \quad (5)$$

where t and i in the model represent the time series as well as cross-section of the panel data respectively, as well as the β is the parameter estimate that express the effect of the respective explanatory variables on the quality of environment. Henceforth, CO_{2it} symbolize the per capita carbon emissions, GDP_{it} stands as the economic growth, GDP_{it}^2 represents the square of economic growth, FDI_{it} standing as the inflow of FDI as well FD_{it} indicates the index of financial development and μ_{it} is a sign of stochastic error term and all the respective series in the model are convert into a form of natural logarithms. Empirically, the expected sign for GDP is positive because economic growth escalates the amount of carbon emissions (Al-Mulali et al., 2015) while for the GDP_{it}^2 the predicted sign is negative following the hypothesis of EKC statement and then the coefficient β_2 and $\beta_3$is expected to be positive and negative. Similarly, FDI is anticipated to either be positively or negatively connect with the amount of carbon emissions on the basis of "Pollution heaven hypothesis" as well as "pollution halo hypothesis", for this reason β_4 could be expected to either positive or negative. The effect of the development of financial sector on the quality of environment is ambiguous. Henceforward, development of financial sector leads to quality of environment deterioration as claimed by Ozcan & Apergis (2018). Development of financial sector is thus essential in lessen the amount of carbon emissions and hence improve the environmental quality as stated by Salahuddin et al. (2015). Following these justification the expected sign for β_5 is either positive or negative.

In order to examine the influence of the driving forces across different class of quantile in the explained variable, the study amend the form of Equation (5) as follows:

$$Q_\tau(lnCO_{2it}) = (\beta_{it})_\tau + \beta_2 GDP_{it} + \beta_3 GDP_{it}^2 + \beta_4 FDI_{it} + \beta_5 FD_{it} + \mu_{it} \quad (6)$$

Where Q_τ and $(\beta_{it})_\tau$ signifies the parameters of the quantile in the explained variable as well as the term of the constant, respectively. In the same vein, $\beta_1, \beta_2, \beta_3, \beta_4 \, and \, \beta_5$ specifies the parameters of the regression of τth quantile inside the dependent series.

3.3.1 Data Source

The set of the data consist the data for environmental quality measured CO_2 emission, economic growth, foreign direct investment as well as financial development that covered the period of 1970-2019 concerning the selected sample of seven leading countries of Africa that consist of Nigeria, South Africa, Egypt, Algeria, Morocco, Kenya, Ethiopia, Ghana as well as Tanzania. The choice concerning h the time covered by the study is based on the data availability. The data for CO_2 emissions in metric tons per capita, GDP constant USD 2010, as well as net inflow percentage of GDP while for the index of financial development lending rate, market capitalization, broad money supply, domestic credit to private sector as a GDP percentage, as well as the domestic credit offered by the banking sector as a GDP percentage were obtained from the data base of World Development Indicator. The statistical explanation concerning the variables use in the study is shown in Table 1 below.

Table 1. Statistical Description of All the Variables

Variable	Mean	Std. Dev.	Min.	Max.
lnCo2	4.618133	0.594647	3.489107	5.701665
lnFD	0.498858	1.440923	-3.72651	2.915973
lnFDI	8.470904	1.007403	4.69897	10.06364
lnGDP	10.63563	0.547357	9.205055	11.75473
lnGDP2	113.4154	11.58216	84.73303	138.1737

Source: Research findings.

4. Results

This section provide the empirical results and the discussion with section 4.1 providing the principal component analysis results while 4.2 section reveals the panel test of unit root concerning the variables of the study. Section 4.3 shows the test of normality and lastly 4.4 section depicts the quantile regression results together with the discussions.

4.1 Principal Component Analysis (PCA)

The composite regarding the indicators of financial development have been constructed through the use of PCA (Principal Component Analysis). The technique serve as a statistical method that is used in constructing single weighted form of index from different but correlated form of variables. In order to take into account different financial development aspect the study use PCA in constructing the complete indices for the variables. PCA is capable of condensing large set of enormously correlated variables into a summarized set of indicators that are correlated which describe a considerable disparities of the original form of data set (Katircioğlu and Taşpinar, 2017).

Table 2. Principal Component Analysis for Financial Development Index

Component	Eigenvalue	Difference	Proportion	Cumulative
1	2.91526	2.02811	0.5831	0.5831
2	0.887146	0.161026	0.1774	0.7605
3	0.726121	0.291608	0.1452	0.9057
4	0.434513	0.397551	0.0869	0.9926
5	0 .036962		0.0074	1.0000

Source: Research findings.

Based on the criteria of Kaiser (1974), the study dropped the form of components that have a less than one eigenvalue and reserved those one that have above one. As revealed in Table 2, Component 1 possess highest share of the variance, while the other components emanate with increasingly lesser share of the remaining variance. Therefore, the first component is hold on the basis of the analysis, this described 58.3% of the variance.

4.2 Unit Root Test

Generally, most of the macroeconomic variables are not stationary. Therefore, if variable is not stationary is used in conducting regression analysis, it would leads regression result that is spurious. Henceforth, the study first undertake the test of stationary for the variables of the study. Hence if the results of the test reveal that variables are not stationary, the variables need to be transform into a form of stationary variables to avoid the occurrence of spurious result.

Table 3. Panel Unit Root Test Results

Variables	IPS		Fisher ADF		Madalla and Wu	
	Constant	**Constant & Trend**	**Constant**	**Constant & Trend**	**Constant**	**Constant & Trend**
lnCo2	-1.3219	-0.1109	-1.4199	1.5252	17.704	8.388
lnFD	-0.8635	-0.0827	-1.1195	0.0778	10.583	8.552
lnFDI	-3.2963*	-3.5125*	-2.6939*	-2.3892 **	7.538*	14.857*
lnGDP	-0.1656	1.0714	-0.3076	0.7408	14.531	7.204
lnGDP2	-0.0780	1.3907	-0.3534	0.9691	14.021	8.143
ΔlnCo2	-18.4409*	-19.1215*	-7.2218*	-6.4641*	41.506*	35.673*
ΔlnFD	-13.7600*	-12.7299*	-8.4625*	-1.6859**	57.266*	36.845*
ΔlnFDI	-21.9099*	-21.5921*	-12.8316*	-11.2375*	101.279*	74.613*
ΔlnGDP	-9.3180*	-10.0126*	-5.0030 *	-4.4914 *	24.893**	29.616*
ΔlnGDP2	-9.1765*	-9.9232*	-4.7615 *	-4.2730*	36.963*	28.254*

Note: *Characterizes significant at 1% confidence level, **symbolizes significant at 5% level of confidence, and ***represents significant at 1% confidence level.

Source: Research findings.

The panel test of unit root are different significantly from the time series test of unit root. The major task of time series test of unit root is to ascertain whether the time series macroeconomic variables are unit root process or trending the stationarity process of the structural breaks. But the effectiveness of the unit root test of time series is not strong, as well the outcome of the different test of unit root frequently vary broadly. For this purpose on the basis of the panel data, theories of econometrics suggested many test of unit root for panel form of data for purpose of overcoming the low effectiveness of the unit root test of time series. Unit root test of panel data are categorized into two classes. The first class of technique is the test of unit root with the similar roots that include test of LLC (Levin-Lin-Chu), test of Breitung as well as test of Hadri. These form of test are on the assumption that the different sequences of cross-section in the panel data possess a common process of unit root. The second class of the technique is the test of unit root with dissimilar roots. These test include test of IPS (Im-Pesaran-Skin), test of Madalla and Wu, as well as test of Fisher-ADF. The test of Fisher-ADF, Madalla and Wu as well as IPS are to relax the homogeneity assumptions and give room for the coefficient of first-order autoregressive to change among different units of observation. In comparison with the first category of the test, the second category of the test is closer to the reality of the objective. Therefore, the current study use IPS, Madalla & Wu and Fisher-ADF tests to conduct the panel unit root test, and the results are shown in Table 3. The results show that most of the variables are non-stationary, but their first-difference series are stationary.

4.3 Tests of Normal Distribution

If the sample of the data is not distributed normally, the results from quantile regression estimation have a robustness that is strong than that estimation from OLS technique. Therefore, before undertaking the regression analysis, the study conduct test of normality for all the variables of the study that is lnCO2, lnfd, lnfdi lngdp and $lngdp^2$ respectively. The test of normality is of two types: the graphical as well as numerical methods. Furthermore, the numerical technique is categorized into descriptive as well as statistical tests.

Firstly, the descriptive statistics, skewness as well as the kurtosis are the two form of descriptive statistics test of normality that are used commonly, which reveal the way the distribution of the series deviates from the normal distribution. (1) Skewness is applied to ascertain the symmetry of the distribution of data. The value of the skewness is equal to 0, it signifies that the data distribution is normal. If the value of the skewness is above 0, this specifies that the pattern of the distribution is skewed to the right distribution, and vice versa. The larger the value of the skewness, the larger the skewness of the data distribution. As revealed from Table 4, the coefficients value of the skewness regarding all the concern variables in the study are not zero significantly. That is to say the variables are not distributed normally. (2) Kurtosis is applied to ascertain the sample data dispersion. If the value of the kurtosis is equal to 3, this signifies that the data is not distributed normally, if the value of the kurtosis is above 3, then the distribution of the data is more discrete, and the vice versa. The greater the value of the kurtosis, the greater the extreme value of the sample data. The empirical outcome from Table 3 reveal that the coefficient of the kurtosis for all the concern variables are not equal 3, this signifies the fact that the variables are not distributed normally.

Secondly, the numerical technique that include the Shapiro-Wilk, Shapiro-Francia and Cramer-von Mises, Kolmo-Gorov-Smirno, as well as Anderson-Darling tests. The test of Shapiro-Wilk (Royston, 1992) as well as Shapiro-Francia (Royston, 1983) are the most used test regularly. Henceforth, the current study applies the two techniques to conduct the test of normality. Table 4 reveals that the p-value of the test of Shapiro-Wilk as well as the Shapiro-Francia are all below 5% level of significance. This signifies that all the concern variables do no follow the normal distribution are the distribution for the variables are left deviation form of distribution. Therefore, all the series not distributed normally.

Thirdly, graphical techniques visually reveals the distribution of the variables, these include (Q-Q) quantile-quantile plot, P-P (Probability-Probability) plot Stem-and Leaf plot, box plot, histogram as well as dot plot. Currently, the study applies the techniques of Q-Q plot to undertake the data distribution test of normality as reveal in Figure 1 for each variable. The straight line that is blue in the figure signifies probability of the series that distributed normally. Hence Figure 1 reveals that the variables observation value depart form the blue straight line. This specifies that the variables are not distributed normally, and the degree of deviation in the recent years increased gradually.

Table 4. Normality Test Results

Variables	Skewness	Kurtosis	Shapiro-Wilk Test		Shapiro-Francia Test		Obs.
			Statistic	Sig.	Statistics	Sig.	
lnCo2	-0.09928	2.050222	5.087	0.00000	4.581	0.00001	350
lnFD	-0.65838	3.041272	5.485	0.00000	5.046	0.00001	350
lnFDI	-0.81092	3.326624	5.940	0.00000	5.515	0.00001	350
lnGDP	-0.22013	2.352646	3.677	0.00012	3.288	0.00051	350
lnGDP2	-0.11914	2.316898	3.362	0.00039	2.959	0.00154	350

Source: Research findings.
Note: Sig. represents the significance level. Obs. indicates the number of observations.

Based on the Table 4 and Figure 1 results, it can be revealed that the variables distribution are not normal as well skewed significantly. Furthermore, the tail of the data distribution encloses essential information that OLS form of regression would not be able to comprehensively reveal. This signifies that applying the regressions model of quantile for the empirical analysis is reasonable and appropriate. The conventional regression of OLS might have biases in the estimation, because OLS is only valid when the variables are distributed normally. In order to avoid the weaknesses of traditional OLS, the current study uses panel techniques of quantile regression.

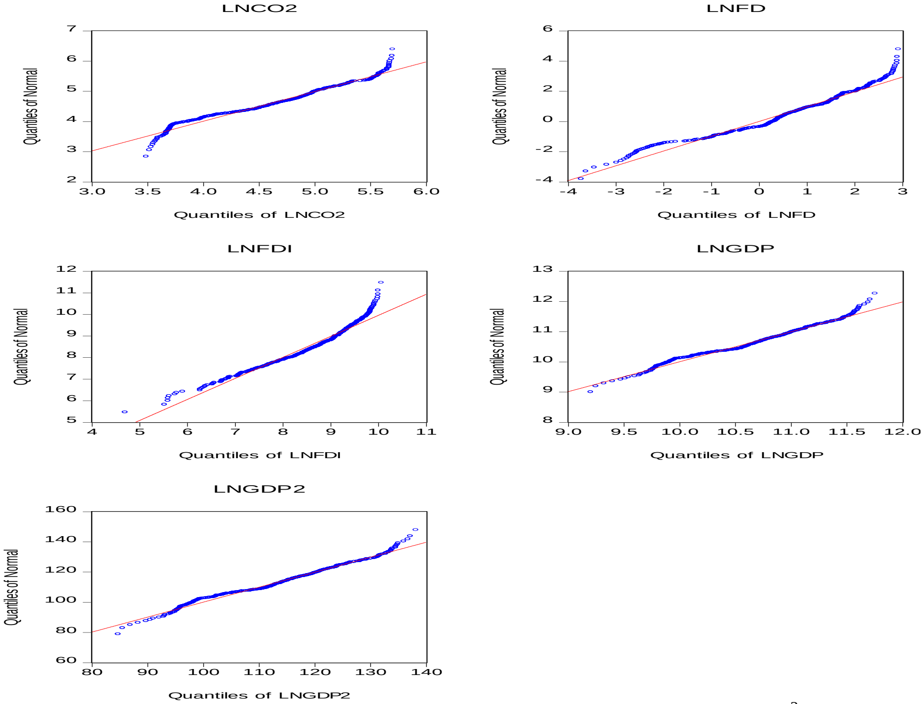

Figure 1. The normal Q-Q plot of lnCO2, lnfdi, lnfdi, lngdp and $lngdp^2$

Source: Research findings.

4.4 Quantile Regression Results

Each class of quantile can describe fully the distribution features of the explained variable, as well as the regression of the quantile can visually show the marginal influence of the independent variables on diverse quantile of the dependent variable. Therefore, the study reveals the regressions of the quantile results of the determinants factors of environmental quality in the leading countries of Africa. In line with the general practice, the study uses five different quantile representatives that is 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} to undertake the quantile regression.

Table 5. Quantile Regression Estimation and Linear OLS Fixed Effects Results

Variables	Quantile Regressions					OLS
	10^{th} Quant	25^{th} Quant	50^{th} Quant	75^{th} Quant	90^{th} Quant	
Intercept	16.445	-5.076	-18.023*	-30.469*	-46.031*	-9.324*
lnFD	0.128*	0.102*	0.134*	0.164*	0.166*	0.039*

Variables	Quantile Regressions					OLS
	10th Quant	25th Quant	50th Quant	75th Quant	90th Quant	
lnFDI	0.098**	0.077	0.117*	0.098*	0.017	0.083*
lnGDP	-0.297	0.110	0.351*	0.598*	0.908*	0.219*
lnGDP2	0.162	-0.026	-0.138**	-0.257*	-0.403*	-0.088*
Pseudo R^2	0.382	0.438	0.468	0.473	0.504	R^2=0.646

Source: Research findings.
Note: *Characterizes significant at 1% confidence level, **symbolizes significant at 5% level of confidence, and ***represents significant at 1% confidence level.

The empirical estimate of the quantile regression results are presented in Table 5 and Figure2 respectively. For the purpose of facilitating the comparative analysis, the study use the results of the OLS estimation that are presented in Table 5 on the last columns. Looking at the significance of the heterogeneous influence of the determinants factors of environmental quality, a discussion that is in depth is delivered. The GDP effect on the amount of carbon emissions is heterogeneous as well insignificant at the 10th and 25th quantile but tend to be positive and statistically significant on the 50th, 75ht as well as 90th quantile. Henceforth, the GDP^2 effect on the quality of environment varies on different classes of quantile with the 10th and 25th quantile that is insignificant while 50th, 75th and 90th have negative coefficients and the coefficients are statistically significant. The GDP and GDP^2 effect on the quality of environment for 50th, 75th, and 90th quantile validate the hypothesis of EKC respectively. The consequence of this outcome is that the group of emitting economies located at the quantile level from the medium to the highest tend to have a form of an economy in which increase in economic growth would lessens the amount of carbon dioxide emissions and enhance the environmental quality. The results foretell an essential policy implications, and is in support of Sarkodie and Strezov (2018) who support the hypothesis of EKC in China that emits a very large amount of carbon dioxide emissions. The finding is also agreeable with the recent empirical research by Usman et al. (2019) that supports the hypothesis of EKC in India, another chief emitter of carbon dioxide emissions.

The effect of the development of financial sector on the emissions of carbon dioxide is heterogeneous as well significant at 1% significance level across all the quantile level. The financial development coefficient is at the 10th quantile higher linked with 25th quantile while the coefficient begin to start escalating from the 25th level of quantile up to the 90th quantile level. Therefore, the results reveal that financial development escalates the amount of carbon emissions, and the results is in support of the previous findings of Ali et al. (2018). Precisely, the findings is consistent with the earlier studies that demonstrate that domestic credit to private sector escalates carbon emissions (Maji et al., 2017; Sehrawat et al., 2015). The finding infers that the financial development effect on the quality of environment is higher on countries with emission of carbon dioxide that is high as well get to be getting low when the emissions level is low. Meaning that countries placed at the high level of quantile tend to have the value of coefficients that is high while those at the lower quantile have low value of coefficients. On the basis of the result the study infer that the selected countries of Africa have financial sector that is efficiently facilitating the transfer of greener technology that will promote the sustainability of environment but the financial sector capability in enhancing the quality of environment tend to be high at the lower level of quantile because of a lower value of coefficients when compared with 75th and 90th classes of quantile that have a high value of coefficients.

However, the effect of FDI on carbon dioxide emissions varies across different classes of quantile as well the 10th , 50th and 75th quantiles are statistically significant while 25th and 90th are insignificant statistically. Therefore, the results of the study support the pollution heaven and hypothesis and also in line with the findings of the previous studies such as (Abdouli et al., 2018; Shahbaz et al., 2019; Sun et al., 2019).

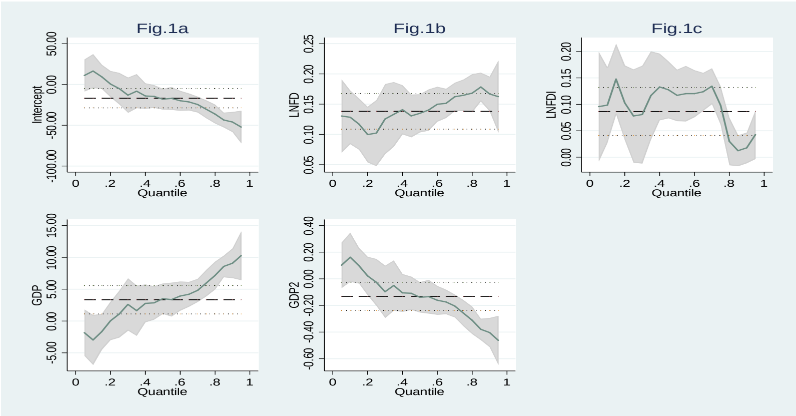

Figure 2. Quantile estimate: The effects of driving forces on the iron and steel industry's CO2 emissions. Notes: Shaded areas correspond to 95% confidence intervals of quantile estimation. The vertical axis indicates the elasticities of the explanatory variables. The red horizontal lines represent confidence intervals of OLS estimation. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article).
Source: Research findings.

5. Conclusion

In this study, the main aim is to examine the effect of economic growth, financial development and foreign direct investment on the quality of environment for the top seven leading African economies. The techniques used for the analysis of the study is the panel techniques of quantile regression that takes into account the unobserved individual heterogeneity as well as distributional heterogeneity. The paper take into consideration the sample period of 1970 to 2019. In comparison with customary mean regression, the study discover that the model of panel quantile regression can give out more details picture concerning the determinants factors of environmental quality. The effect of economic growth on the quality of environment is insignificant on the 10th and 25th but positive and significant on the 50th, 75th and 90th quantile. Likewise the square of economic tend to have insignificant effect on the 10th and 25th quantile but effect is negative and significant on the 50th , 75th and 90th quantile. This justify the presence of EKC hypothesis on the 50th, 75th and 90th quantile. The result regarding the foreign direct investment reveals heterogeneous effect on the quality of environment with 25th and 90th having insignificant effect while 10th, 50th and 75th having positive and significant effect. Henceforth in relation to financial development the effect on the quality of environment is positive and significant across all the quantiles but with a varying degree of coefficients.

Lastly, the study adds not only to existing knowledge but also provide a significant policy implication for both the policy makers and the government as well. Economic growth is positively related with carbon emissions, revealing the detrimental effect of economic on the degradation of environment. Such kind of environmental degradation would affect human health that would ultimately decline the level of productivity and hence affects the economic growth rate. At the same time, the square of economic growth have a negative relationship with the amount of carbon emissions, meaning that after reaching a certain point increase in economic growth would enhance the quality of the environment, for this the study support the hypothesis of EKC. As a policy suggestion, some measures must be put in place for decreasing pollution of environment devoid of any sacrifice for these countries economic growth. The following are the proposed steps of achieving the objectives. These measures involve the alteration of regulations that are related with decreasing the carbon emissions emanating from the industry, transport and the use of fossil fuels. Enhancing the alternative sources of energy like wind and solar energy projects, applying carbon confiscation technologies in power plants as well as supporting green investment via the application of environmental technologies.

Henceforth, FDI deteriorate the quality of the environment as stated by the outcome of this study. As FDI increases emissions of carbon dioxide emissions also increase, more efforts are required for the preservation of environment in Africa. The African countries should inspire the use of technologies that are friendly with the environment to increase the level of production domestically. The government should also limit the issuance of license to polluting foreign industries like pharmaceutical and chemical firms as well as foundries that emit large amount of carbon dioxide emissions. At the same time the countries of Africa should make use of policies that would encourage inflow of FDI particularly on the service sector rather than polluting firms since it is essential for economic growth stimulation and the policies that would control environment-FDI relationship and lessen environmental emissions should be enforced in African countries.

Furthermore, while the development of financial sector deteriorate the quality of environment, financial institutions in Africa should inspire firms or industries to make investment in project that friendly with the environment and make the provision of credit at a lower arte to firms or industries that are complying or committed to invest in a project that are environmentally sustainable. In addition, future policies of environment should make it compulsory for industries and firms to reveal their environmental performance. Other policy instruments should be use by the environmental policymakers like emissions cap or trading as well as carbon emissions tax for carbon emissions mitigations.

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