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The effect of economic factors on the quality of the environment in African countries: An application of panel quantile regressions

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Abstract

Background: To mitigate the climate change, several researches have been conducted to determine the determinant factors of CO_2 emissions. Nonetheless, a consensus was failed to reach yet on the issue because many of the previous studies did not deliberate the undetected individual heterogeneity across countries. The study aimed to investigate the effects of economic growth, foreign direct investment and financial development within the research background of seven leading African economies over the 49-year period from 1970 to 2019.

Methods: In this study, the determinant factors of environmental quality were examined by employing a panel quantile regression. The advantage of the method is considering the distributional heterogeneity to provide a detailed description regarding the driving factors of carbon emissions.

Results: It was revealed that the effects of determinants on CO_2 emissions are heterogeneous. The quantile regression estimate describes that the influence of economic growth on CO_2 emissions is positive and higher at the 50th quantile than in other classes of quantile. The effect of financial development on CO_2 emissions is higher and positive at the 90th quantile compared to other categories of quantile. The FDI influence on CO_2 emissions is heterogeneous across different quantiles and the coefficient is significant and larger at the 10th quantile than in all the other quantiles.

Conclusion: In addition, the study recommends that environmental policies that minimize emissions should be enforced for the purpose of making the environment cleaner, FDI should be environmentally friendly, and relevant incentives are required to redirect private credits towards green projects and renewable energy development.

Keywords: Economic growth, FDI, Financial development, Environment, Quantile regression

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Introduction

The most challenging and debated issue of environment that has recently attracted the attention of policymakers is global warming (1). The escalation of carbon emissions as well as the absorption of greenhouse gases (GHGs) within the atmosphere that leads to global warming that is severe for both human and economic development. Emissions of carbon dioxide (CO_2) is the leading source of GHGs that leads to global warming (2). Based on the studies conducted by many researchers, emissions of CO_2 is recognized as the major source of pollution that leads to high rate of death in developing economies (3). It has contributed greatly to cardiovascular diseases as well as respiratory diseases. According to the report of the World Health Organization (WHO), air pollution accounts for 7 000 000 deaths each year (4). The escalation of temperature results in a series of adverse consequences, such as rising level of sea, the ozone layer damage as well as the regular incidences of dangerous weather events (5). All these have a negative effect on the stability of the ecosystem of the earth and threaten the human survival (6).

Therefore, the efforts of the international organization to mitigate the antagonistic impact of global warming result in policies of minimizing the level of CO_2 emissions (7,8). In spite of the concentrated efforts to reduce the absorption of CO_2 emissions on the earth, global carbon emissions have been rising. According to a study by IEA, 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 (9). The region of Africa is not an exception regarding the escalation

of CO_2 emissions from 884.53 million tons in 2000 to around 1.19 billion tons in 2010 as well from 1.23 billion tons in 2012 to 1.29 billion tons in 2015 and the amount escalated to 1.33 billion tons in 2017 (10). 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 (7). IEA reported that the global escalation of carbon emissions is due to robust global economic growth, weak effort in efficient use of energy as well as the lower price of fossil fuel (11).

The activities of macroeconomic variables discharge large amount of CO_2 emissions that leads to its high concentration rate in the atmosphere (12). Likewise, carbon emissions influence on the global warming is anticipated to be carried on in the future (13). Many factors involve in the global growth of CO_2 emissions including population, economic growth, industrialization, FDI, financial development, energy production and consumption (14-16). The extent to which each of these factors contributes to CO_2 emissions in the atmosphere varies from one region to another depending on the extent of the existence of these factors in a country. The examining and understanding of how these factors influence the concentration of CO_2 emissions is vital for necessary environmental policy making.

Literature review showed that several studies have investigated the relationship between economic growth, financial development, foreign direct investment, and the quality of environment (17-38). Also, it was revealed that there is no study that applied PCA techniques as well fives indicators of financial development as a single index, particularly in Africa. Furthermore, previously used techniques of estimation that support OLS (ordinary least squares) assumptions of normality distribution are 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 present study makes methodological contribution through using quantile regression analysis techniques as used by few of the previous studies. In addition, most of the previous studies that consider economic growth, foreign direct investment, and financial development on the quality of environment have concentrated on developed and industrialized countries and few studies concentrated on developing countries, especially Africa.

Finally, the present study contributes to the environmental literature in these respective ways: The lack of consensus concerning the influence of economic growth, foreign direct investment, and financial development on the quality of environment is the primary motivation for conducting the present work to deliver more evidence. Different from the earlier studies, the recent study has applied the principal component analysis (PCA) to construct index of financial development that encompasses five different financial development indicators such as broad money, lending rate, market capitalization, domestic credit to private sector as a GDP percentage, and the domestic credit offered by the banking sector as a GDP percentage. The main reason for constructing the index of financial development is to resolve multicollinearity problem and overcome the shortcomings of single indicator as a financial development indicator.

Similarly, unlike the earlier studies, this research applied quantile regression model to examine the major determinant factors of environmental quality in the selected sample of African countries. In comparison with traditional estimation of OLS, quantile regression not only serves as an improvement of the model robustness, but also, disclose essential information on the tail of the distribution of the data, and also, to obtain a clear portrait of the sample data, particularly for the data that are not normally distributed. Precisely, this research focused predominantly on two essential issues. First, the reason for which the present study used the quantile regression model to examine the effects of economic growth, foreign direct investment, and financial development on the quality of environment in Africa. Second, the effect of these determinants on the quality of environment under different categories of quantile.

Materials and Methods

Quantile regression model

The method of quantile regression model was first made onward by Koenker and Bassett (39). Therefore, quantile regression would undertake conditional estimation of quantile in which each particular function pronounces behavior of each particular points in the conditional form of distribution. The theoretic content of the model of panel data is 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, X stands as the vector of the explanatory series, π is the stochastic error term that has a conditional distribution of quantile as zero. Hence, $Quant_\varphi\ (Yi/X_i)$ signifies φ^{th} quantile for Y that is the explained variable. The approach of quantile regression enables the determination of the effect of covariate across diverse location in the dependent variable distribution.

The φ^{th} estimator of the quantile regression is $\hat{\rho}_\varphi$, which serves as the solution for the following equation:

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

The overhead equation acquires a solution through the linear programming. The regression of the median is

quantile regression special case that is generated through the assumption that ϕ = 0.5. Different quantiles can be obtained by setting different values of ϕ as revealed in Eq. (3). Therefore, for the purpose of expressing the possible relationship between the independent variables as well as the different form of conditional distribution of the dependent variable, the study set different classes of quantiles (10^{th}, 25^{th}, 50^{th}, 75^{th}, and the 90^{th}). The study can make use of bootstrap technique suggested by Buchinsky to generate the parameter's standard deviation in the quantile regression (40). The regression of quantile is one of the essential technique of estimation because of its robustness as well as consistency, especially when the stochastic error term contained heteroscedasticity and is not distributed normally.

Model specification and data source

The study aimed to examine the relationship between economic growth, financial development, and foreign direct investment with the quality of environment using the EKC model. The EKC model reveals different environmental quality parameters in relation to changes in income. It is suggested that at the earlier phases of economic growth, issues related to pollution and natural resources degradation are likely to take place. This process will proceed until a particular level of per-capita income is reached, and then, the process proceed in a reversible way that is higher income leading to enhancement of the quality of environment. Following the studies by Al-Mulali et al (24) and Hanif (41), the following functional form of EKC equation was applied:

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

Where $lnCO_2$ is the CO_2 emissions that measure the quality of the environment as the explained variable, Y, Y^2, and Z represent 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 determinant 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. The model is turned into the 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 are the time series and cross-section of the panel data, respectively, β is the parameter estimate that expresses the effect of the respective explanatory variables on the quality of the environment. In addition, CO_{2it} is the per capita carbon emissions, GDP_{it} is the economic growth, GDP_{it}^2 represents the square of economic growth, FDI_{it} is the inflow of FDI, FD_{it} is the index of financial development, and μ_{it} is a sign of stochastic error term; all the respective series in the model are converted into a form of natural logarithm. Empirically, the expected sign for GDP is positive because economic growth increases the amount of carbon emissions (23) while for the GDP_{it}^2, the predicted sign is negative following the hypothesis of EKC statement, and then, the coefficients β_2 and β_3 are expected to be positive and negative, respectively. Similarly, FDI is anticipated to be either positively or negatively connected with the amount of carbon emissions on the basis of "pollution haven hypothesis" as well as "pollution halo hypothesis", for this reason, β_4 could be expected to be either positive or negative. The effect of the development of financial sector on the quality of environment is not clear yet. Henceforward, development of financial sector leads to deterioration of quality of environment as claimed by Ozcan et al (42). Development of financial sector is thus essential in reducing the amount of carbon emissions, and hence, improving the environmental quality as stated by Al-Mulali (24). 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 classes of quantile in the explained variable, the study amend the form of Eq. (6) as follows:

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

Where Q_τ and $(\beta_{it})_\tau$ are the parameters of the quantile in the explained variable and the c3onstant, respectively. In the same vein, β_1, β_2, β_3, β_4, and β_5 show the parameters of the regression of τth quantile inside the dependent series.

Data source

The set of the data consist the data for environmental quality measured CO_2 emission, economic growth, foreign direct investment, and financial development during 1970 to 2019, concerning the selected samples of seven leading countries of Africa (Nigeria, South Africa, Egypt, Algeria, Morocco, Kenya, Ethiopia, Ghana, and Tanzania). 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 database of World Development Indicator (WDI). The statistical description of the variables used in this study is shown in Table 1.

Results

This section provides the empirical results and the discussion, which comprise the PCA results, the panel test of unit root, the normality test, and lastly, the quantile regression results, together with the discussions.

Principal component analysis

The composite regarding the indicators of financial development has been constructed through the use of PCA. The technique serves 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 aspects, in this study, PCA was used in constructing the complete indices for the variables. PCA is capable of condensing a large set of enormously correlated variables into a summarized set of indicators that are correlated and describe a considerable disparities of the original form of data set (43).

Based on the criteria reported by Kaiser (44), the study dropped the form of components that have an eigenvalue less than one and reserved those that have an eigenvalue above one. As revealed in Table 2, Component 1 possesses the 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, which described 58.3% of the variance.

Unit root test

Generally, most of the macroeconomic variables are not stationary. Therefore, if non-stationary variable is used in conducting regression analysis, it would lead to spurious regression results. Therefore, in this study, first, stationary test for the variables of the study was performed. If the results of the test reveal that variables are not stationary, the variables need to be transformed into a form of stationary variables to prevent the occurrence of spurious results.

The panel test of unit root are significantly different from the time series test of unit root. The major purpose of unit root test is to determine whether the macroeconomic variables are stationary or not and at what level. For this purpose, on the basis of the panel data, theories of econometrics suggested many tests of unit root for panel form of data to overcome 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 similar roots that include test of LLC (Levin-Lin-Chu), test of Breitung, and test of Hadri. These tests are based on the assumption that 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 tests include test of IPS (Im-Pesaran-Shin), test of Madalla and Wu, and test of Fisher-ADF. The tests of Fisher-ADF, Madalla and Wu, and IPS are to relax the homogeneity assumptions and allowed 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, in the present study, IPS, Madalla and Wu, and Fisher-ADF tests were used 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.

Table 1. Statistical description of all the variables

Variable	Mean	Standard deviation	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.

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.

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 stronger than those from OLS technique. Therefore, before undertaking the regression analysis, test of normality was performed for all the variables of the study, which are lnCO2, lnfd, lnfdi lngdp, and $lngdp^2$, respectively. The test of normality is of two types: Graphical and numerical methods. Furthermore, the numerical technique is subcategorized into descriptive and statistical tests.

Firstly, the descriptive statistics, skewness and kurtosis, are two forms of descriptive statistics test of normality that are commonly used, which show the distribution of the series deviates from the normal distribution. Skewness is applied to ascertain the symmetry of the data distribution. 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 indicates 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 shown in Table 4, the coefficients value of the skewness regarding all the concerned variables in the study are not zero significantly, indicating that the variables are not distributed normally. Kurtosis is applied to ascertain the sample data dispersion. If the value of kurtosis is equal to 3, this signifies that the data are not distributed normally, if the value of kurtosis is above 3, then, the distribution of the data is more discrete, and vice

versa. The greater the value of the kurtosis, the greater the extreme value of the sample data. The empirical outcome from Table 3 reveals that the coefficient of kurtosis for all the studied variables are not equal 3, indicating that the variables are not distributed normally.

Secondly, the numerical techniques include the "Shapiro-Wilk", "Shapiro-Francia" and "Cramer-von Mises Kolmogorov-Smirnov", as well as "Anderson-Darling" tests. The test of Shapiro-Wilk (45) and Shapiro-Francia (46) are the most commonly used tests. Therefore, in the present study, the two techniques were applied to conduct the normality test. Table 4 reveals that the P-value of the Shapiro-Wilk and the Shapiro-Francia tests are all below 5% significance level. This signifies that all the concerned variables do no follow the normal distribution. Therefore, all the series were not distributed normally.

Thirdly, graphical techniques visually reveal the distribution of the variables, which include quantile-quantile (Q-Q) plot, probability-probability (P-P) plot, Stem-and-Leaf plot, box plot, histogram, and dot plot. In this study, the Q-Q plot was applied to perform normality test in order to determine the data distribution; the results are shown in Figure 1. The blue straight line in the figure signifies the probability of the series that distributed normally. Hence, Figure 1 reveals that on each variable, the blue line departs from the red straight line. This specifies that the variables are not distributed normally, and the degree of deviation in the recent years has been increasing gradually.

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, quantile regression was used in the present study.

Quantile Regression Results

Each class of quantile can comprehensively describe the distribution features of the explained variable, and the quantile regression can visually show the marginal influence of the independent variables on diverse quantile of the dependent variables. Therefore, the study reveals the quantile regression results of the determinants factors of environmental quality in the selected countries of Africa. In line with the general practice, in this study, five different quantile representatives (10^{th}, 25^{th}, 50^{th}, 75^{th}, and

Table 3. The results of Panel unit root test

Variable	IPS		Fisher ADF		Madalla & Wu	
	Constant	Constant and trend	Constant	Constant and trend	Constant	Constant and 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*

*Significant at 1% confidence level, **Significant at 5% confidence level.
Source: Research findings.

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

Sig: Significance level, Obs: Number of observations.
Source: Research findings.

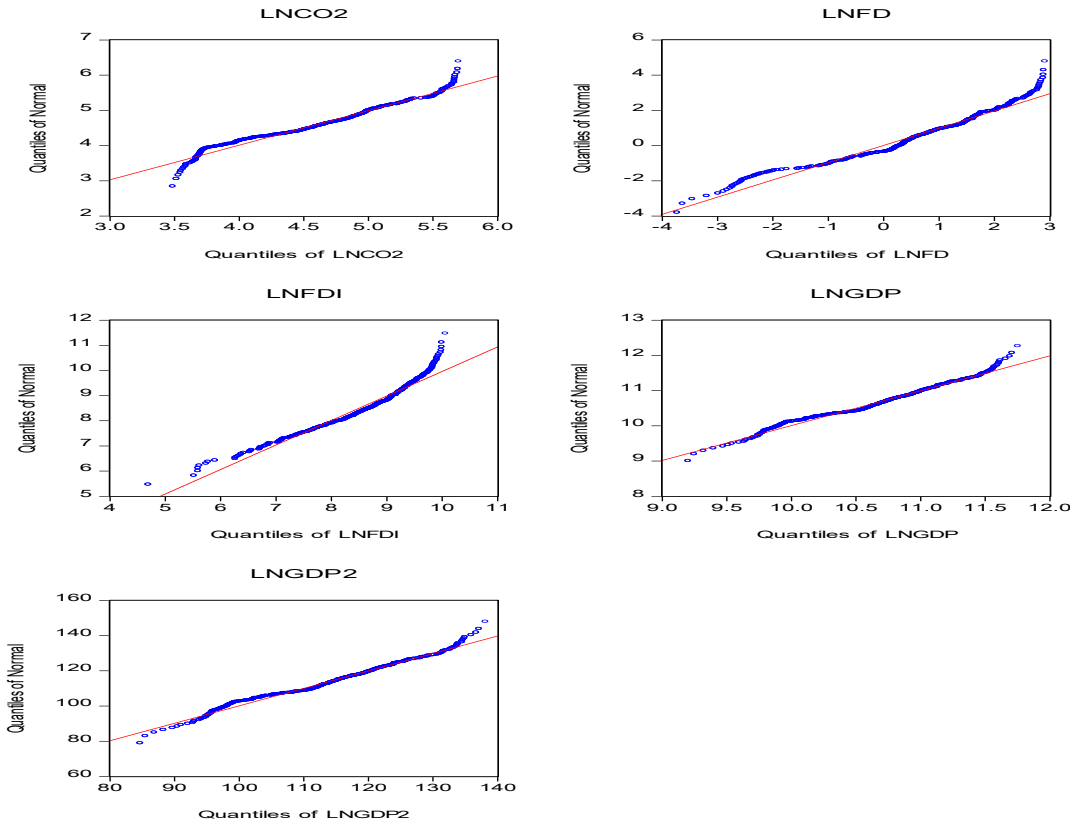

Figure 1. The normal Q-Q plot of lnCO2, lnfdi, lnfdi, lngdp, and lngdp^2. Source: Research findings.

90th) were used to perform the quantile regression.

The empirical estimates of the quantile regression results are presented in Table 5 and Figure 2, respectively. To facilitate the comparative analysis, in this study, the results of the OLS estimation that are presented in Table 5 on the last columns, were used. Regarding the significance of the heterogeneous influence of the determinants factors of environmental quality, an in-depth discussion is delivered. The effect of the development of financial sector on the emissions of CO_2 is heterogeneous and significant at 1% significance level across all the quantile levels. The financial development coefficient is higher at the 10th quantile and linked with the 25th quantile while the coefficient begin to escalate 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, which is consistent with the results of previous studies (47), indicating that domestic credit to private sector escalates carbon emissions (26,48).

However, the effect of FDI on CO_2 emissions varies across different classes of quantile, and the 10th, 50th, and 75th quantiles are statistically significant while the 25th and 90th quantiles are statistically insignificant. Therefore, the results of the study support the pollution haven hypothesis, which is consistent with the findings of previous studies (35,49). Similarly, the GDP effect on the amount of carbon emissions is heterogeneous and insignificant at the 10th and 25th quantiles but tends to be positive and statistically significant on the 50th, 75th, and 90th quantiles. Therefore, the GDP^2 effect on the quality of environment varies on different classes of quantile with the 10th and 25th quantiles are insignificant while the 50th, 75th, and 90th quantiles have negative coefficients that are statistically significant. The effects of GDP and GDP^2

Table 5. Quantile regression estimation and linear OLS fixed effects results

Variables	Quantile regressions					OLS
	10th Quant	25th Quant	50th Quant	75th Quant	90th 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*
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

*Significant at 1% confidence level, **Significant at 5% level of confidence, and ***Significant at 1% confidence level.

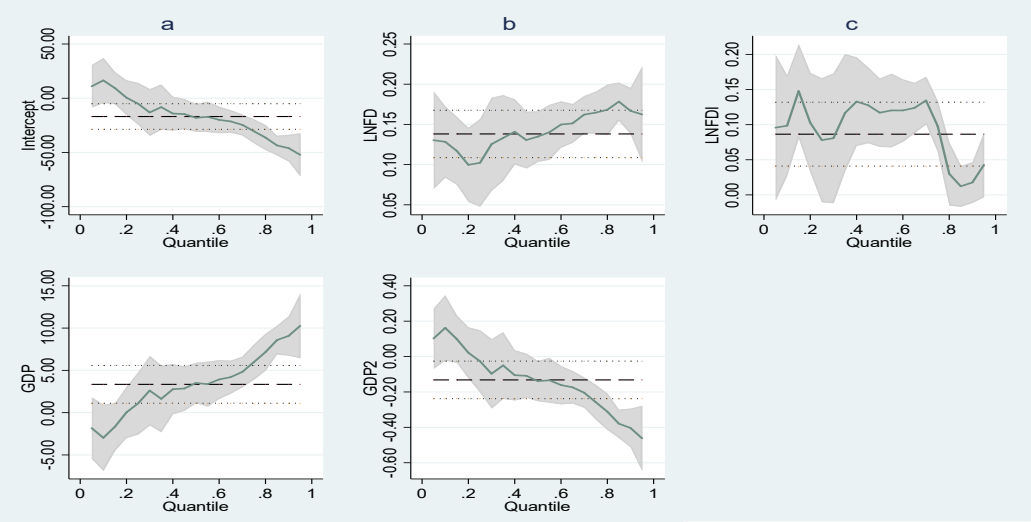

Figure 2. Quantile estimate; the effects of driving forces on CO_2 emissions by the iron and steel industry. Notes: Shaded areas correspond to 95% confidence intervals of quantile estimation. The vertical axis indicates the elasticities of the explanatory variables. The red horizontal lines represent 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

on the quality of environment for the 50th, 75th, and 90th quantiles validate the EKC hypothesis, respectively. The consequence of this outcome is that the groups of emitting economies located at the quantile level from the medium to the highest ones tend to have a form of an economy in which an increase in economic growth would lessen the amount of CO_2 emissions and enhance the environmental quality. The results foretell an essential policy implications, which is consistent with the results of a study by Sarkodie et al (50) that support the EKC hypothesis in China that emits a very large amount of CO_2 emissions. The finding is also consistent with the results of a recent empirical research by Usman et al (51), which supports the EKC hypothesis in India, another chief contributing country to CO_2 emissions.

Discussion

Economic growth had a statistically significant influence on CO_2 emissions in the African countries. Economic expansion was primarily driven by fast industrialization, which resulted in increased CO_2 emissions. This was due to government measures aimed to expand the manufacturing sector and create more jobs. As a result, industrial and building activities increased in these countries. The industrial sector in African nations includes major subsectors such as manufacturing and construction, which have been identified as the worst contributors to global CO_2 emissions in studies. The current debates indicate that, while increasing the industrial sector's proportion of GDP in these countries was economically advantageous, it came at a cost to the region's environment. The region's dangerous CO_2 emissions levels were exacerbated by a surge in industrial and building activities. This statement confirms the result reported by Ehigiamusoe et al(52) in the case of middle-income countries, those that aspire to achieve more rapid economic development and faster economic growth need and use more energy for commercial, industrial, residential, and agricultural activities, which has a greater negative impact on carbon emissions than countries consuming less energy. For this reason, in another study by Zhang et al (53), the necessity for nations to increase investment in renewable energy projects was underlined to reduce pollution, because renewable energy is more environmentally friendly.

However, the findings of the present study show that FDI increases human ecological demands, and foreign plants established in African countries may not use efficient production methods, which require more resources and energy, resulting in increased environmental degradation. This result confirms the presence of PHH in the African countries. This result is consistent with the results reported by Shahbaz et al (54) indicating that attracting FDI inflows will assure economic expansion through the consumption of fossil fuel energy (scale effect), resulting in an increase in CO_2 emissions. In other words, in these growing nations, the scale impact dominates the sector, validating the PHH for MENA. But inconsistent with the findings reported by Vitenu-Sackey (55) in the case of West and Southern Africa, the analysis rejects the factor endowment hypothesis and the pollution haven hypothesis in both regions, but accepts the halo effect hypothesis in both. This might also imply that inflows of foreign direct investment into these two locations are not always directed to the industrial sector, which consumes a lot of fossil fuels; fossil fuels have been identified as the source of the most carbon emissions.

Finally, the findings of the study show that the effect of financial development on the quality of environment is higher on countries with higher CO_2 emission levels, and lower on countries with lower CO_2 emission levels. This means that countries placed at higher levels of quantile tend to have high coefficient values while those at lower

levels of quantile have low coefficient values. The results of the present study show that the selected countries of Africa have a financial sector that is efficiently facilitating the transfer of green technology that will promote the sustainability of the environment but the financial sector capability in enhancing the quality of environment tends to be high at lower levels of quantile because of a lower coefficient value compared with the 75th and 90th classes of quantile that have a high coefficient value. The findings support the findings of a study by Acheampong et al (56) indicating that a financially-developed market facilitates technological innovations that reduce environmental degradation, as well as providing reputational and financial incentives for firms or industries to invest in environmentally beneficial projects. On the other hand, the findings are inconsistent with those reported by Gök (57) indicating that financial development accelerates industrialization, which raises industrial pollutants and GHG emissions

Conclusion

In this study, the main aim was 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 taken into consideration the sample period of 1970 to 2019. The study shows that the panel quantile regression model can give out more detailed picture concerning the determinant factors of environmental quality. The effect of economic growth on the quality of environment is insignificant on the 10th and 25th quantiles but positive and significant on the 50th, 75th, and 90th quantiles. Likewise, the square of economic growth tends to have an insignificant effect on the 10th and 25th quantiles but the effect is negative and significant on the 50th, 75th, and 90th quantiles. This justifies the presence of the EKC hypothesis on the 50th, 75th and 90th quantiles. The result regarding the foreign direct investment reveals heterogeneous effects on the quality of environment with the 25th and 90th quantiles having insignificant effects while the 10th, 50th, and 75th quantiles have positive and significant effects. Henceforth, in relation to financial development, the effects on the quality of environment is positive and significant across all the quantiles but with a varying degree of coefficients.

Lastly, the study adds knowledge not only to the existing knowledge but also provides a significant policy implication for both policymakers and the government. Economic growth is positively related with carbon emissions, revealing the detrimental effect of economics 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 has a negative relationship with the amount of carbon emissions, meaning that after reaching a certain point increase in economic growth, it would enhance the quality of the environment, which support the EKC hypothesis. As a policy suggestion, some measures must be put in place for reducing the environment pollution without any sacrifice for the economic growth of these countries. The following steps are the steps proposed for 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 will improve the quality of environment.

According to the results of this study, FDI deteriorates the quality of the environment. As FDI increases, CO_2 emissions also increase, more efforts are required for the preservation of the environment in Africa. The African countries should inspire the use of environmentally friendly technologies to increase the level of production domestically. The government should also limit the issuance of license to polluting foreign industries like chemical and pharmaceutical industries as well as factories that emit large amount of CO_2 emissions. At the same time, the African countries 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. Also, the policies that would control environment-FDI relationship and lessen environmental emissions should be enforced in African countries.

Policy Recommendations

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

Despite this, the findings of this study seem reasonable; nonetheless, the study has some limitations. One of these limitations is that there was lack of data for several variables. As a result, it was impossible to include factors

such as energy price and other disaggregated energy variables, and the timeframe of the study is limited to 2019. Furthermore, due to the lack of data, the study was confined to only seven African countries. As a result, future studies could expand the model by including other important variables related to green energy resources such as thermal, wind, solar, and hydro when data are available, and also, could extend the study's period to cover up to 2021 with other African countries taken into account.

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Ethical issues

The authors confirm that all data acquired during the research is as stated in the paper, and no data from the study has been or will be published elsewhere.

Competing interests

The authors declare that there is no conflict of interests.

Authors' contributions

Data collection, analysis, and interpretation were all done by all authors. The manuscript was reviewed, revised, and approved by all authors.

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