

Environmental Degradation and Economic Growth in African Low-Income Economies

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Abstract

The paper examined the validation of the environmental Kuznets curve hypothesis on the relationship between economic growth on environmental sustainability in African low-income economies, with a focus on the influence of financial system development and the speed of urbanization in the classification, using data from the World Development Indicator on panel ARDL-AMG techniques. The results of the unit root tests indicate that the variables are of mixed integration order, while the cross-sectional dependency test established the existence of cross-sectional dependence among the cross sections. The results of the cointegration test revealed the presence of a long-run relationship in the overall model, which further justifies the adoption of the panel second-generation unit root test, which also showed a consistent conclusion with the first generation. Following this mixed integration order and the treatment of cross-sectional dependence problem, the results of the adopted AMG technique adopted to analyze these relationships showed that environmental Kuznets curve was validated by the significant positive and negative values of GDPpc and GDPpc squared respectively suggesting an inverted U- shape nonlinear connection between economic growth and environmental sustainability, with negligible positive and negative contributions from urbanization and financial development respectively in low-income Africa economies.

Keywords: Carbon emissions, GDP per capita, financial development, urbanization.
JEL CODES: O44, Q01, Q50

INTRODUCTION

Attention had been shifted towards the environment's quality alongside the state of economic growth in terms level of productivity, which was the central idea of the enforced Kyoto Protocol in 2005; there exists an inverted U relationship between environmental pollution and economic growth as suggested by the environmental Kuznets curve. This hinges on the fact that during the first stage of industrialization, pollution along the curve would increase quickly due to the quest for more wealth than a clean and hygienic environment; consequently, environmental regulation is lax. As income increases, a higher value is placed on the environment with more enforced regulations causing pollution levels on the curve plateau in middle-income civilizations to decline toward pre-industrial levels in wealthy societies.

There are significant policy implications in the existing relationship between environmental protection and growth in any economy. If there exists an inverse relationship between improved productivity and the level of environmental pollution, households would act in a way to protect their inhabited ecosystem by limiting economic activities. Unregulated growth and usage of vehicles and equipment in the transportation and manufacturing sectors in emerging economies have resulted in traffic and facilities emissions of high percentages of greenhouse gases (GHGs) such as Nitrogen dioxide (NO₂), Carbon monoxide (CO₂), and methane in these economies. This is not unconnected to poor maintenance practices and importation of outdated vehicles and equipment, which resulted in an automotive fleet dominated by a type of vehicles known as "super emitters" in the transport sector and "mega emitters" in the manufacturing sector, with significant emissions of dangerous pollutants, causing a worrisome situation of weak economic standing in these countries. However, economic activities would be boosted if the duo were positively related because such increased economic activities would simultaneously result in improved environmental conditions. In the end, economic expansion will help to enhance environmental quality.

The literature on environmental deregulation and economic growth has been quite fascinating and seems majorly skewed towards the support of the Environmental Kuznets Curve hypothesis. Al-Mulali et al. (2015) investigate the ecological footprint of a nation as a measure of environmental deterioration with the sole aim of validating the Environmental Kuznets Curve (EKC) hypothesis. The Ninety-three nations that were investigated were grouped based on income level. In upper-middle- and high-income countries, but not in low- and lower-middle-income countries, the outcomes of the generalized method of moments (GMM) and fixed effects demonstrated the existence of an inverted U-shaped bond between the ecological footprint and GDP growth, substantiating the EKC hypothesis.

Similarly, an inverse relationship was advocated to exist between an improved financial system and environmental quality, such that improvement in the financial industry tends to worsen environmental quality. Empirical studies suggest that natural resources and economic growth have a significant positive short- and long-term relationship with the ecological footprint (Zia et al. 2021). Additionally, this shows how China's natural resources and economic development are linked to an increase in ecological impact. Besides, human capital intensifies the harmful impact on the

environment. Ecological footprints increase as a result of economic expansion, but the findings also revealed an intriguing finding that supports the presence of the environmental Kuznets curve in China.

By measuring emissions of sulfur dioxide (SO₂), chemical oxygen demand (COD), and ammonia nitrogen, the study of Zeraibi et al. (2021) primary objective to investigate the effects of government spending, economic growth per capita, environmental protection expenditures and added second-sector value on environmental quality. The findings showed a large direct impact of government spending on raising environmental quality across the board in Chinese regions, an effect that grows with the rate of economic expansion. The inverted U-shaped association between the pollution factor and economic growth per capita was also supported by the data.

Rahman and Alam (2022) look at how 17 Asia-Pacific nations' CO₂ emissions are affected by their energy use, economic expansion, financial development, and cross-border commerce. The obtained results showed that CO₂ emissions from the panel countries are increased by factors like energy consumption, financial development, economic growth, and trade, while they are decreased by factors like the square of economic growth, ultimately supporting the environmental Kuznets curve (EKC) hypothesis.

Investigating how environmental degradation is affected by the influence of economic growth and financial development in a few developing countries in the Island from 2000 to 2016, Seetanah et al. (2019) study reveals a long-run cointegration, in which there is a negative and significant effect of GDP per capita on emissions. This implies that economic development reduces the level of environmental degradation in the selected Island countries. In the study, the environmental Kuznets curve was validated by the evidence of long-run income elasticity being lower than its short-run counterpart. Though FD insignificantly impacts on CO₂ emissions, the combined effect of economic growth and Financial Development on environmental degradation is indicative of the fact that financial development tends to exhibit a positive impact on the environment, with Island economies achieving a reasonably high-income level as well.

Besides, Charfeddine and Khediri (2016) extend the work of Shahbaz et al. (2014) by using the recent unit root tests as well as the multiple structural breaks and regime-switching cointegration techniques for one and two unknown regime shifts to investigate the relationship between carbon dioxide emissions, electricity consumption, economic growth, financial development, trade openness, and urbanization in the United Arab Emirate (UAE) from 1975 to 2011. The findings demonstrate the existence of the Environmental Kuznets Curve (EKC), with the existence of an inverted U-shaped association between financial progress and CO₂ emissions. They also discover that increased power usage, urbanization, and trade openness help to enhance environmental quality.

However, the evidence about FIN's effect on CO₂ has been contradictory, depending on the developmental state of the economy. FIN lowers CO₂ by promoting and funding lower-cost technological adoption and innovation (Ehigiamusoe et al., 2019), while in Ehigiamusoe and Lean (2019), the relationship between FIN and carbon

emission (CO₂) varies based on countries' income group. This was the outcome of their study of 122 economies on the nexus between the duos, and the study discovered that financial development improves environmental quality for high-income countries, while it exacerbates the environmental quality of low-income countries. Al-Mulali et al. (2015) examine both the long-run relationship between carbon emission and financial development in Latin America and Caribbean economies. They ascertain that an improvement in the financial sectors of these economies mitigates carbon emissions only in the long run.

Similarly, Shahbaz et al. (2013) examine the existing relationship among energy use, economic growth, financial development, trade openness, and CO₂ emission in Indonesia. Their findings support the cointegration of the variables, which suggests that even in the face of structural fractures, the long-term link persists. The empirical results show that while financial development and trade openness reduce CO₂ emissions, economic expansion and energy use raise them.

The nature of the relationship between gaseous emissions and income has been under increased discussion since the Kyoto Protocol was ratified. The question of whether limiting emissions will likely hinder economic growth has dominated much of this discussion. A thriving financial system industry (FIN) might increase investments and encourage industrialization, which would increase pollution by using more energy (Baloch et al., 2021; Ehigiamusoe et al., 2019). FIN is connected to the environment since it increases the number of goods, intermediaries, and financial services that can encourage greater energy demand and consequent pollution (Katircioglu and Taspinar, 2017). For instance, an effective financial system might foster conditions where consumers can get more credit or loans, which would enable them to increase their demand for long-lasting carbon-emitting goods (such as cars and electronic equipment), further worsening degradation (Jalil and Feridun, 2011). This was also evidenced in Fu (2001), and Kumar and Goyal (2018), in an empirical study of developing countries, in which it was estimated that between 50 and 80 percent of carbon dioxide emission (CO₂) concentration in such countries is caused by traffic emissions.

Theoretical literature places a strong emphasis on the effects of urbanization (URB) on the environment. The compact city ecological modernization, and urban environmental transition theories, for instance, explain how URB affects the environment (Nathaniel, 2020; Martinez-Zarzoso and Maruotti, 2011). URB suggests a system of social evolution that signifies modernity, because growth occurs at the expense of environmental sustainability, as environmental challenges arise, society transitions from low- to middle-income economies. The detrimental effects of urban expansion could, however, be lessened with increased technical innovation (Mol and Spaargaren, 2000). It is against this background, the study focuses on the validation of the Environmental Kuznets Curve hypothesis, with emphasis on financial system development and speed of urbanization in African low-income countries.

METHOD

The theoretical framework of the study is the popular environmental Kuznets curve model, which demonstrates how environmental quality (CO₂) is affected by economic growth per capita (GDPpc). The functional relationship between these two variables is expressed below in equation (1):

$$CO_2 = f(GDPpc, GDPpc^2) \quad (1)$$

Econometrically, this quadratic relationship is then modeled as:

$$LCO_{2it} = \beta_0 + \beta_1 LGDPpc_{it} - \beta_2 LGDPpc^2_{it} + \beta_3 CONT_{it} + \varepsilon_t \quad (2)$$

Where $CONT_t$ represents the vector of control variables and ε_t denotes the white noise of the model. To obtain the threshold value of GDPpc necessary to clean up the economy, the first partial of equation (2) is taken; this is shown below:

$$\frac{d(LCO_2)}{d(LGDPpc)} = \beta_1 - 2\beta_2 LGDPpc = 0 \quad (3)$$

$$2\beta_2 LGDPpc = \beta_1 \quad (4)$$

$$LGDPpc = \frac{\beta_1}{2\beta_2} \quad (5)$$

Find the exponential value of equation (5) to eliminate the logarithmic effects of the model.

$$GDPpc = e\left(\frac{\beta_1}{2\beta_2}\right) \quad (6)$$

Model Specification

The relationship for the study's objectives can be functionally modeled as:

$$CO_{2it} = \alpha_0 + \alpha_1 GDPpc_{it} + \alpha_2 GDPpc^2_{it} + \alpha_3 URBAN_{it} + \alpha_4 FDI_{it} + \alpha_5 FIN_{it} + \mu \quad (7)$$

Taking the natural log form of these variables to have a uniform unit of measurement and estimate coefficients in the form of elasticity, Equation (7) is thereby re-written econometrically, which will be used to express the stated objectives in equations 2 and 3 to be:

$$InCO_{2it} = \alpha_0 + \alpha_1 InGDPpc_{it} + \alpha_2 InGDPpc^2_{it} + \alpha_3 InURBAN_{it} + \alpha_4 InFDI_{it} + \alpha_5 InFIN_{it} + \mu \quad (8)$$

Where: α_0 is the intercept depicting carbon emission when the explanatory variables are equal to zero. While α_1 , α_2 , α_3 , α_4 , and α_5 are the coefficients or parameters of the explanatory variables.

The time series cross-section data on carbon emission metric tons per capita, foreign direct investment inflow, urban population, financial industry development proxied by the ratio of M2 stock of money to GDP, and Gross Domestic Product per capita were represented as (CO₂), (FDI), (URBAN), (FIN) and (GDPpc), respectively. The exogenous variables in the model are justified on the grounds of being part of supply-side macroeconomic variables that directly or indirectly contribute to environmental deregulation. The inclusion of the white noise or stochastic error term (μ_t) in the above model is to capture the impact of other variables that are not included in the model.

Using Eberhardt and Bond's Augmented Mean Group (AMG) method (2009). This method was chosen because of the AMG estimator's inherent ability to handle important statistical features like cross-sectional dependence and non-stationarity. This is possible because the model distinguishes between dynamic observed effects and potential unobserved effects in the model (Adekoya et al., 2022)

The AMG procedure involves two stages, specified as follows:

Stage 1:

$$\Delta Y_{it} = \delta_i + \beta_i \Delta X_{it} + \tau_i f_i + \sum_{t=2}^T \theta_i \delta \Delta B_t + \varepsilon_{it} \quad (9)$$

Stage 2:

$$\hat{\beta}_{AMG} = N^{-1} \sum_{i=1}^N \hat{\beta}_i \quad (10)$$

Where θ_i is the parameter of the common dynamic process, captured by the time dummy variable, B_t , and Y_{it} represents each of the dependent variables, X_{it} includes all of the regressors, and ε_{it} denotes the unobserved heterogeneous common factor.. Also, $\hat{\beta}_{AMG}$ represents the AMG estimator.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 1 reports the properties of the underlying variables employed in the study. The means of all the variables in the data set fall within the minimum and maximum values, indicative of a normal distribution (bell shape) of the variables. In addition, the standard deviation that was used to measure the spread or dispersion of the data showed that GDP was the most widely dispersed variable. By implication, GDP has been unstable over the study period between 1980 and 2023.

Table 1. Descriptive Statistics

Variables	Observations	Mean	Std. Dev.	Minimum	Maximum
CO ₂	864	0.2788	0.2919	0.0172	1.7634
FDI	864	2.4829	4.4678	-30.9478	46.2752
GDPpc	864	902.7427	530.9368	190.2342	2679.555
URBAN	864	32.6361	13.3568	5.416	68.283
FIN	864	16.631	4.1330	2.210	27.168

Source: Author's Computation (2024).

Unit Root Tests

Having considered the statistical properties of the underlying series, it is imperative to examine the stationarity properties of individual variables. This is achieved through the unit root test. The purpose of this test is to detect if the employed variables or series are stable over time (Sun *et al.* 2017). A variable is considered stable and can be used for decision-making if it does not have a unit root at its level state, while a non-stable series has a unit root at its level state.

Table 2. First-Generation Unit Root Test

Variables	Levin, Lin and Chu T* Test				Remarks
	Level		First difference		
	Intercepts	Trend	Intercepts	Trend	
CO ₂	-2.3507	-1.9858**	-21.9290***	-17.8264***	<i>I(0)</i>
GDPpc	-6.8901***	-3.7975	-21.1101***	-16.2152	<i>I(0)</i>
FDI	-12.0854***	-0.1183	-19.3116***	-11.0989	<i>I(0)</i>
URBAN	11.5632	11.3374	-32.6548***	-7.1726***	<i>I(1)</i>
FIN	-22.7688***	12.8145***	-16.5562***	-7.6872***	<i>I(0)</i>

Note: a and f are the t-statistics of the unit root test at levels and first differences, respectively, while *** and ** are the 1% and 5% levels of significance.

Table 2 reveals the results of the various unit root tests employed. Using the Levin, Lin and Chu first-generation unit root test, it was discovered that all the variables except URBAN proved significant at 1% level of significance in their level state. As such, we can reject the null hypothesis of no unit root. In other words, these variables are stable in their level form. This implies that the enlisted variables do not have unit roots at their level form except for URBAN. Conclusively, it can be affirmed that the variables employed have mixed order of integration, i.e., while some are stationary at their level states, others are stationary at their first differences.

Cross-Sectional Dependence Tests

In most panel studies, time series data for different cross-sectional units may be related to one another due to either weak or strong unobserved factors, or spillover or spatial effects; this invariably may produce biased estimates or results that cannot be used for decision-making (Sarafidis and Wansbeek, 2021). Aside from this, it also determines the choice of an appropriate estimation technique that will be used in achieving the study's objective. More so, this test determines whether to examine the second-generation unit root test. Thus, it is necessary to conduct the cross-sectional dependence test to determine this.

Table 3. Cross-Sectional Dependence Test

Test	Statistic	Probability
Breusch-Pagan LM	1873.484	0.0000
Pesaran Scaled LM	56.3334	0.0000
Pesaran CD	-2.1992	0.0279

Source: Author's Computation (2024).

Table 3 reports three cross-sectional dependence statistic tests: The Breusch-Pagan LM, the Pesaran-Scaled LM and the Pesaran CD. From the results, the null hypothesis of no cross-sectional dependence can be rejected at a 1% level of significance for Breusch-Pagan LM and Pesaran-Scaled LM tests, while this can be rejected at 5% level of significance for the Pesaran CD test. The study can therefore infer that there is a presence of cross-sectional dependence among the cross-sections, judging from the fact that the probabilities of these tests are less than the chosen level of significance.

Second-Generation Unit Root Test

The second generation of panel unit root tests aims to remedy the first-generation tests' insufficiency of cross-sectional dependence (Khraief et al., 2020). Table 4 reports the results of the Harris-Tzavalis unit root test, which considers the trend-intercept and intercept forms of the unit root test. The result shows mixed integration order for the model.

Table 4. Second-Generation Unit Root Test

Variables	Harris-Tzavalis Unit-Root Test				Remarks
	Level		First Difference		
	Intercepts	Trend	Intercepts	Trend	
CO ₂	0.9278	0.7348*	-0.0387***	-0.0127***	<i>I(0)</i>
GDPpc	0.9742	0.8104	0.0385***	0.1016***	<i>I(1)</i>
FDI	0.4353***	0.3806***	-0.2998***	-0.3006***	<i>I(0)</i>
URBAN	1.0045	0.9422	0.6944***	0.8493	<i>I(1)</i>
FIN	-0.2965***	0.9976	0.8213	0.4462***	<i>I(1)</i>

Note: ***, ** and * represent the 1% 5% and 10% levels of significance.

Cointegration Test

Having established the stationarity level of individual series, it is germane to test for the long-run joint significance of the model. On this note, the study adopts the cointegration test of Westerlund (2005) to examine this joint significance, which is then presented in Table 5. It is revealed from this table that we cannot accept the null hypothesis of no cointegration, since the probability is less than 5% level of significance. Hence, the model has a long-run relationship. We can proceed to estimate the Augmented Mean Group (AMG) for this study.

Table 5. Westerlund Cointegration Test Result

	T-Statistic	P-Value
Variance Ratio	-1.7927	0.0365

Source: Author's Computation (2024).

Having corrected the problem of cross-sectional dependence and established the existence of cointegration, the study proceeds to apply the Autoregressive Distribution Lags-Augmented Mean Group (ARDL-AMG) technique to unravel the

extent to which economic growth influences environmental quality in the low-income countries of Africa, as reported in Table 6.

In Table 6, it was revealed that GDPpc exerts a significantly positive influence on CO₂, while there is a negative and significant impact on CO₂ from GDPpc squared, in such a manner that 1% increase in GDP will raise the level of CO₂ by 22.28 % points, while 1% increase in GDPpc squared will reduce the level of CO₂ by 1.68 % points. These results validate the Environmental Kuznets Curve hypothesis, suggesting an inverted U-shaped non-linear relationship between GDPpc and CO₂. At the initial stage of development, a percentage increase in GDPpc will aggravate CO₂, but this tends to decline after the attainment of a certain threshold level of economic development has been reached. A feasible justification for this in low-income African countries is probably the employment of pollution-prone production techniques at the early stage of development, which, due to technological advancement, stringent environmental regulations/laws, and increased awareness of the need for environmental protection, have improved environmentally friendly production techniques. This finding aligns with that of empirical studies, such as Ehigiamusoe et al. (2021); Zakaria and Bibi (2019).

Table 6. AMG Results

Regressors	Dep. Var. = CO ₂			
	Coefficient	Std Error	Z-Statistic	P> Z
GDPpc	22.2780	11.1311	2.00	0.045
GDPpc ²	-1.6800	0.8601	-1.95	0.051
FDI	-0.0082	0.0067	-1.23	0.218
URBAN	0.2041	0.2443	0.84	0.803
FIN	-0.1067	0.1361	-0.78	0.443
Constant	-82.3860	38.4984	-2.14	0.032

Source: Author's Computation (2024).

Financial system development (FIN) and foreign direct investment (FDI) show an insignificant negative effect on carbon emissions in this region. The reason for this insignificant relationship is that FDI inflow and financial system development in this region have not received much attention due to the low level of development, and such will not have a significant effect on the region's environmental sustainability. This same reason is also applicable to the urbanization-carbon emission (URBAN), which is insignificantly positive since the region is less developed.

CONCLUSION

Sequel to the indicated results, the study concludes that there is a significant relationship between economic growth and carbon emission, as well as the validation of the Environmental Kuznets Curve (EKC) in low-income African economies. This is evident in the positive relationship between GDPpc and carbon emission (CO₂), alongside the negative relationship between GDPpc-squared and carbon emission in African low-income economies, with negligible positive and negative contributions from urbanization and financial system development (FID), respectively.

This suggests that GDPpc and CO₂ have an inverted U-shaped non-linear connection, thereby confirming the EKC hypothesis. At the early stage of economic development, an increase in GDP will aggravate CO₂. But after a certain threshold level of economic development is attained, a further rise in GDP will mitigate CO₂. The plausible justification for this finding is that low-income African countries probably employed pollution-intensive production methods at the early stage of economic development. But at the later stage of economic development, the countries embrace environmentally friendly production techniques due to technological innovations, stringent environmental regulations/laws and increased awareness of the need for environmental protection.

FID shows an insignificant negative effect on carbon emission in this region, because it has not received much attention due to the low level of development, and such will not have a significant effect on the region's environmental sustainability. This same reason is also applicable to the urbanization-carbon emission, since the region is less developed. This conclusion is supported by empirical studies such as Zakaria and Bibi (2019) and Ehigiamusoe, *et al* (2022).

The policy implication of the study is that GDPpc growth can mitigate CO₂. As a result, African low-income countries may reduce CO₂ by increasing their GDPpc, which needs an enabling environment and efficient regulatory mechanisms to control environmental pollution. Thus, the study recommends that African low-income countries should encourage urbanization with caution in a way that will not have detrimental effects on the environment. It is also observed that FDI negatively drives carbon emissions negligibly. Due to this, the region should improve its infrastructural facilities, which will encourage the pollution halo hypothesis¹.

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¹ Pollution Halo Hypothesis posits that foreign direct investment lead to a decline in emissions.

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