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Research article

Does financial globalization uncertainty affect CO_2 emissions? Empirical evidence from some selected SSA countries

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Abstract: Based on the Environmental Kuznets's Curve theory, this study seeks to investigate the asymmetric relationship between the financial globalization uncertainty and the environmental quality alongside the test of Kuznets's hypothesis. The research covers the data set of nine Sub Saharan African countries from 1980−2019. The Kuznets's hypothesis of the relationship between economic growth and the environment quality has been validated, identifying the pivotal point of the relationship's transition. The results further reveal that the positive shock of FGU is inversely related to CO_2 emissions, implying that as the foreign capital flow increases, the accompanying CO_2 emissions decreases. Whereas, the negative decomposed component of the financial globalization uncertainty indicates a negative and significance coefficient. While, renewable energy reduces the deterioration of the environmental quality. In the last part of the study, policy implications are recommended accordingly.

Keywords: environmental Kuznets curve; panel NARDL model; environment quality; financial development

JEL Codes: F64, F65

1. Introduction

Productivity growth has generally increased as a result of the globalization phase, and financial development which has been quite effective in the productivity growth process is also experiencing a positive nod following the economic globalization (Erdogan et al., 2020). However, rapid manufacturing and financial growth have contributed to the increase in energy use and emissions respectively. As such, primary energy use as at 2018 rose in by 2.9 percent, almost twice its estimated 10-year annual average rate of 1.5 percent (BP, 2019). In addition, a dramatic rise in greenhouse gas (GHG) emissions has been caused by recent increases in global energy usage (Danish et al., 2020). In 2018, levels of atmospheric carbon dioxide (CO_2) increased by 2.0% and reached 33,890 million tons, marking the highest growth in the last seven years (BP, 2019). CO_2 emissions that account for 65% of GHG emissions have been caused by the use of fossil fuels and industrial activities (Intergovernmental Panel on Climate Change IPCC, 2014). Many studies have concentrated on the impact of globalization, economic growth, and financial progress on environmental quality because of the declining ecosystem and growing knowledge of improving and preserving environmental quality. Globalization refers to the financial openness and economic reforms element that increases the attractiveness of large inflows of foreign direct investment-related research and development (Dauvergne, 2008).

The manufacturing sector has been the major engine of economic growth in many nations since the early 19th century's Industrial Revolution. The use of machinery and technical inputs in the manufacturing process has contributed to a remarkable and significant shift in the economic interactions between people in formerly agricultural societies, leading in exponential rapid economic development. Industrial economic development, however, has generated problems with environmental deterioration, and the convergence of industrial processes has been a significant contributor to climate change. The average world temperature rose by almost 0.87 °C first from late nineteenth century, but as per the 2018 report of the international panel on climate change (IPCC), meanwhile climate and environmental extremes were found to occur more strongly amid the rise in world temperature by 0.5 °C. These issues are exacerbated by anthropogenic greenhouse gases that have socioeconomic and ecological effects in the form of more vague weather, increased severity of catastrophic events, severe drought in many areas, sea level rise due to the melting of polar ice caps, proliferation and extinction of many living organisms, and impairment of human health (IPCC, 2018).

Global warming is one of the big challenges in today's environment that has the ability to ruin sustainable productive capacity in both developing and developed nations. The environmental emission of carbon dioxide and other greenhouse gases is the primary cause for climate change. These greenhouse gases contribute to global warming, and the atmosphere across the globe is affected by global warming. Therefore, understanding the driving forces of CO_2 emissions is important. Our study aims to evaluate the determinants of CO_2 emissions, and special interest is given to the level of global financial uncertainty. carbon emissions are closely linked to industrial development and fossil fuel burning (Grossman and Krueger, 1991). Earlier studies have suggested that income (usually calculated by the per capita gross domestic product) has a major effect on environmental quality (Kuznets, 2019). However, income can reduce the amount of environmental pollution in developing countries, as health and other problems that may be more essential than the rate of per capita income or economic strength may be regarded by policymakers in these nations. In addition, emissions of the atmosphere and greenhouse gases, contributing to anthropogenic climate change, are affecting sustainable economic development in both developed and emerging economies. A greater number of per capita income or

productivity expansion would increase the carbon emissions intensity. However, as per capita GDP grows, policy makers should be more concerned about carbon emission. Policymakers should have a more environmentally friendly manufacturing process at this point, and this systemic transformation would reduce the rate of growth of Carbon emission. This viewpoint was modelled by Grossman and Krueger (1991); Al-Mulali et al. (2015) as the environmental kuznets curve (EKC). The empirical findings revealed that large economic output would cause the amount of greenhouse gas emissions to increase until a developed country has a particular per capita GDP level.

At this stage, we include the level of global financial uncertainty as a new driving factor of CO_2 emissions in these selected SSA countries. In other words, we extend the EKC model with the FGU and address a possible omitted variable bias. Indeed, researchers have indicated that uncertainty decreases investments (Ozturk et al., 2020; Özokcu and Özdemir, 2017; Atasoy, 2017). The waves of uncertainty regarding CO_2 emissions, however, seem to be ignored by empirical literature. We propose that uncertainty about financial globalization can have a negative or positive impact on the process of carbon emission in an open economy. Our hypothesis is driven by the fact that an open economy comprises of energy-intensive commodity use and expenditure in energy. At this point, a higher level of FGU could lead to a decline in energy usage and pollution-intensive goods, thereby reducing CO_2 emissions as FGU increases.

Unrestrained international capital flows are core aspects of the present international economic market, the so-called Dollar-Wall Street regime. To the Us dollar which is at the forefront of the international currency hierarchy (Gowan, 1999), but also to certain nations that have a high place within the world currency hierarchy, the structure offers a huge advantage to capitalist core countries, especially to the USA. In order to enforce conditionality on nations, external debt and financial dependence are central points of entry. Conditionality also demands that nations be more open to international investment and financial flows, and that public infrastructure and natural wealth be privatized, thus reducing the national policy capacity (Soederberg, 2014). Moreover, debt and fund investment flows appear to increase uncertainty and financial crisis vulnerability (Bortz and Kaltenbrunner, 2018).

Trans-border foreign investment to developing economies, like green finance, are also particularly problematic against the backdrop of a developmentalist outlook, leading to uncertainty and a net outflow of wealth from the center to the core countries. Moreover, they will promote access to and enhance the transfer of domestic environmental assets to the world's core nations. This eliminates external vulnerability and potentially promotes strategies of productive (green) aggregation. Since CO_2 is really the main greenhouse gas released from human activities, responsible for 76% of the total carbon emissions (IPCC, 2014), several research efforts anchored on the principle of the EKC used Carbon emissions as the variable that indicates the extent of environmental harm, such as in the studies of Atasoy (2017); Sinha and Shahbaz (2018). Some studies in the past have shown that the concentration of CO_2 is a result of several factors besides sales and productivity expansion. As domestic credit improves financial access for businesses with a mission to build environmentally sustainable technologies or to manufacture environmentally friendly goods, it helps to minimize potential deterioration of the environment.

On the contrary, financial development would increase CO_2 emissions by itself in favor of economic growth (Shahbaz et al., 2013; Pata, 2018). In addition, the industrialization of the national economy has been found to increase CO_2 emissions either directly or indirectly due to the use of energy in the additive manufacturing process and the intensive use of energy in other fields following the

process of economic growth and urbanization (Liu and Bae, 2018). Moreover, as foreign investors transfer global capital into those economies, the degree of financial expansion rises. The influence of financial globalization uncertainty towards environmental degradation in the case of developing economies deserves a significant research interest, more especially the selected SSA countries.

Consequently, the primary aim of this research is to investigate the effect of the financial globalization uncertainty in relation to carbon emissions. Nine SSA countries have been chosen for the data analysis, including the Congo Republic, Zimbabwe, Botswana, Kenya, Nigeria, South Africa, Sudan, Togo, and Senegal. Furthermore, the study provides a clearer understanding whether or not the various socio-political backgrounds and economic systems of the various countries or economic blocks have ramifications for the functioning of the EKC and the association between productivity growth and the environmental quality. In addition to checking the validity of the EKC hypothesis, this research also has a secondary objective of evaluating the effects of other variables on the level of CO_2 emissions beyond economic growth. By so doing, this study uses the nonlinear pool mean group model to test the EKC hypothesis, as it can directly capture the nonlinear relationship between instability of financial globalization, economic growth, renewable energy and environmental quality. This asymmetric nature of the study coupled with its uniqueness in terms of financial globalization uncertainty determinant to CO_2 emissions makes the current study different from the previous studies.

This article is organized into six sections. Section 1 is the introduction that provides the context and sense of the environmental analysis. The EKC literature, related research, and the factors influencing the levels of CO_2 emissions are discussed in Section 2 and the EKC theory is defined. The definition of the regression model is dealt with in section 3. The data and variables used in the analysis are explained in Section 4. The main study findings are presented in Section 5. Section 6 gives conclusions and recommendations.

2. Related theory and research works

2.1. The environmental kuznets curve (EKC) hypothesis

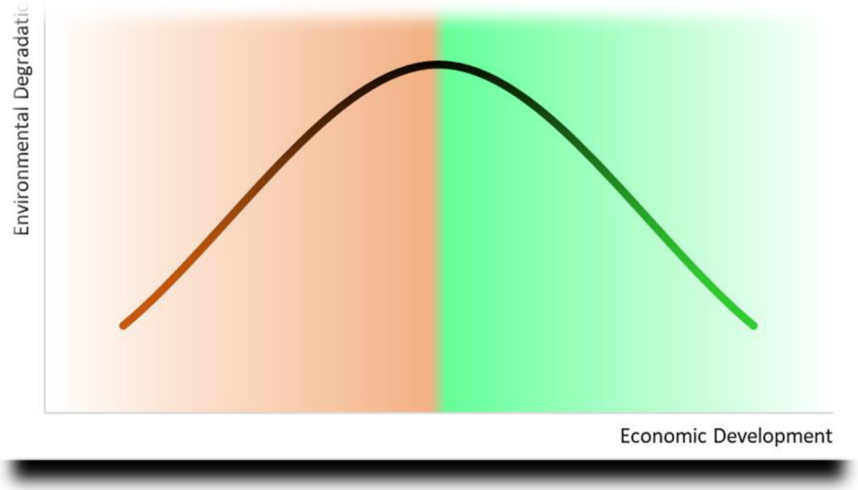

Figure 1. The environmental Kuznets's curve.

The theory of the environmental Kuznets's curve describes an inverted U-shaped association between economic growth and environmental destruction (Figure 1), environmental contamination pressure rises in the early phases of growth due to excessive pollutants and the widespread and intense use of natural resources coupled with increased utilization of production resources up to a particular stage, as revenue increases; and afterwards, it declines, perhaps due to the increasing public consciousness and concern with regards to environmental destruction and the efforts of research and development are more geared towards the idea of the green economy as production increases at a greater extent (Stern, 2004; Kaika and Zervas, 2013).

2.2. Literature review

In recent years, scholars have drawn attention to the association between the growth of the financial sector and environmental deterioration. Many studies show strong evidence that finance induces increased greenhouse gas emissions (Cetin et al., 2018a; Paramati et al., 2018; Ali et al., 2019; Dar and Asif, 2017; Xing et al., 2017; Javid and Sharif, 2016; Charfeddine and Khediri, 2015). Firstly, the growth of the stock exchange would help listed firms strengthen their funding sources, decrease financing costs, reduce operational risk, make new projects, and thereby maximize the use of energy and CO_2 emissions. Secondly, financial expansion could increase environmental emissions by increased amounts of foreign direct investment inflows. Eventually, the country's developed financial system makes the country more attractive to the foreign investors, and the influx of these foreign investors are usually associated with increased productions that results to higher rates of carbon emissions. This is because studies have shown that most of the foreign investors prefer investing in these developing countries because of their weak environmental regulations (Raza & Shah, 2018).

On the other hand, some studies have observed that financial development increases the energy output and productivity of the sector, thereby significantly reducing energy use and emissions of carbon dioxide (Saud et al., 2019; Ghorashi and Rad, 2018; Dogan and Seker, 2016; Al-mulali et al., 2015; Salahuddin et al., 2015). In addition, Katircioğlu and Taşpinar (2017) documented a unidirectional causality in the context of Organization for Economic Cooperation and Development economies between financial development and carbon emissions. The results of Zaidi et al. (2019) verified the Cooperation Countries' bidirectional causality between financial development and environmental quality in Asia Pacific. In much the same vein, Farhani and Ozturk (2015) discovered a unidirectional causal relationship between financial development and carbon emissions for Tunisia. And Zafar et al. (2019) discovered a unidirectional relationship between greenhouse gases and financial development for OECD economies.

There is a correlation between CO_2 emissions and economic growth. Studies have shown that as a nation experiences productivity growth in the early phases of economic progress, carbon emissions increase, but decrease after achieving a certain degree of economic prosperity (Charfeddine and Mrabet, 2017; Ahmad et al., 2017; Al-Mulali et al., 2015). However, earlier studies identify the relationship between sustainable growth and environmental degradation as conflicting, such as a report by Yeh & Liao (2017) for Taiwan, Boufateh (2019) for the United States, Ma and Jiang (2019) for China, Aye and Edoja (2017) for 31 developed countries and Acheampong (2018) for 116 economies across the world found that CO_2 emissions declined with an increase in the productivity growth. Similarly, Ozcan (2013) also offers some support for the reduction in carbon emissions with an increase in actual per capita GDP. However, Omri et al. (2015) and Charfeddine and Mrabet (2017) for MENA countries,

Begum et al. (2015) for Malaysia, Ahmad et al. (2017) for Croatia, Dong et al. (2018) for China, and Al-Mulali et al. (2015) for Vietnam among others have demonstrates that an uptick in economic activity is capable of rising energy consumption and thereby exacerbating CO_2 emissions.

Amidst the context of rising worries about global warming, the role of renewable energy in the battle against pollution has been thoroughly examined in different countries and regions. Yet another literature stream including Lin and Zhu (2019); Danish et al. (2019); Hanif et al. (2019); Nathaniel and Iheonu (2019); Chen et al. (2019); Dong et al. (2018); Pata (2018); Zambrano-Monserrate et al. (2018); Sinha and Shahbaz (2018); Liu et al. (2017); Zoundi (2017); Shahbaz et al. (2017); Al-Mulali et al. (2016); Bilgilli et al. (2016); Ben Jebli et al. (2016); Sugiawan and Managi (2016); Al-Mulali et al. (2015a); Bölük and Mert (2015) have shown inconclusive results. Most of the studies have found renewable energy to play a positive role in fostering economic growth and improving the atmosphere by mitigating CO_2 emissions through the use of green energy. Destek and Sinha (2020) conducted one of the uncommon and most recent studies that recognizes ecological footprint as the dependent variable for verifying the reliability of the EKC hypothesis for 24 nations exploiting panel data from 1980 to 2014 in the Organization for Economic Co-operation and Development economies. The research used econometrics estimation approach such as panel mean-group (MG), FMOLS-MG and Dynamic Ordinary Least Squares-MG estimators to determine the regressor coefficients, acknowledging panel heterogeneity. The approximate coefficients invalidate the reliability of EKC in the panel.

The scientific exercise, however, supports the emission-mitigating effect of renewable energy by triggering an EF downward wave. Non-renewable energy was, however, found to produce an upsurge in EF. An analytical exercise was initiated by Danish and Ulucak (2020) to assess the feasibility of the Ecological Footprint derived EKC model employing panel data for the BRICS nations over the year 1992 to 2016. By integrating green energies, urbanization and environmental resources rent, the authors increased the EKC base model. For the data estimation, dynamic panel estimation techniques such as FMOLS and DOLS estimators were used. The result confirmed the involvement of the EKC in the BRICS. Renewable technology has also been found to have an inhibitory impact on the environmental footprint. Alola et al. (2019a) adds to the scientific literature on the role of green energy as its main indicator in enhancing environmental sustainability, taking into account the ecological footprint. They perform a panel analysis using data from 16 European Union countries for the year 1997 to 2014 and examine them with the introduction of the Pooled Mean Group regression technique. The outcomes of the research confirm the beneficial role of renewable energy, assessed by EF, in the environmental protection.

3. Methodology

3.1. Data description

In this study, we use the data on metric tons per capita to measure CO_2 emissions (Farouq and Sulong (2021b); Dabachi et al., 2020; Jakada et al., 2020a; Jakada et al., 2020b; Jakada Mahmood and Ahmad, 2020), meanwhile the measure of financial globalization uncertainty as widely used by Ahmad et al. (2018); Danlami et al. (2018); Farouq et al. (2020); Farouq and Sulong (2021a) among others to the FGU_{it-1} that represents the lagged one period of foreign direct investment inflows. With the actual values of the residuals obtained by regressing the FDII on its lagged value with a time trend refers to the volatility of the financial globalization, while economic growth is measured using real GDP

(Farouq et al., 2020; Farouq and Sulong, 2020a; Farouq et al., 2021), finally the Renewable energy is the natural log of percentage share of renewable energy in aggregate final energy usage. The study is based on the panel dataset that covers the year from 1980 to 2019. The data for all the concern variables have been sourced from the world development indicator (2021).

3.2. Methodology and model specification

The objective of this paper is to analyze the possible asymmetric linkage between financial globalization uncertainty and quality of environment in nine selected sub-Saharan African countries by focusing on one main research objective: does the financial globalization uncertainty asymmetrically sensitive to the quality of environment? The econometric framework is based on the stochastic properties and the heterogeneity of the data analyzed. For that purpose, the Pesaran's (2007 and 2006) unit root test that considers cross-sectional dependence and allows testing for heterogeneity are presented. Secondly, after testing for unit root, the symmetric cointegration test is implemented (Westerlund, 2007). Thirdly, we present in vivid details the estimation technique namely the nonlinear panel PMG model.

The financial development-CO_2 emission relationship is traditionally explored in previous research using the auto-distributive lag model (ARDL) cointegration study of ordinary time series approaches and the conventional PMG for panel results followed by Granger's modelling error correction (EC) and causality. However, the aforementioned econometric methods allow the evaluation of the presence of long-run relationships followed by short-run interactions, while the linkage between finance and environmental quality is symmetrical. Over this, they are not sufficient to obtain asymmetries of imaginable variables. Via the use of the Nonlinear Pooled Mean Group (NPMG) method developed by (Shin et al., 2014), this research then explores the short-term as well as the long-term asymmetric relation between financial globalization uncertainty and environmental quality, with positive and negative partial sum decompositions of the explanatory variable. This approach has the value of separating the explanatory factors under review between short-term and long-term asymmetric reactions to adjustments in environmental emissions. In this variable's logarithmic transition, the shift in the variable being evaluated is defined as the first variation. The asymmetric relationship of cointegration can be expressed as follows:

$$C0_{2it} = F(FGU_{it}, GDP_{it}, GDP_{it}^2, RWE_{it}) \tag{1}$$

All the variables are transformed into logarithmic form. The log-linear functional form of the empirical equation is as follows:

$$lnC0_{2it} = \beta_1 + \beta_2 lFGU_{it} + \beta_3 lGDP_{it} + \beta_4 lGDP_{it}^2 + \beta_5 lRWE_{it} + e_{it} \tag{2}$$

where CO_2 is carbon emissions representing the quality of environment, FGU specifies financial globalization uncertainty, GDP denotes economic growth, RWE illustrates renewable energy, and β= (β_1, β_2, β_3, β_4+, β_5−) is a vector of unknown parameters.

We build the nonlinear panel ARDL model of Shin et al. (2014) in panel term, which is really a nonlinear reflection of the hierarchical heterogeneous data panel model suitable for large T panels. We have followed this method for three reasons. Firstly, it helps the study to capture nonlinear asymmetries. Secondly, it accounts for the intrinsic variability impact of the results as we have seen for the financial globalization uncertainty. Third, it is more fitting if there is an existence of a unit root or a mixed

convergence order of not more than I (1). Asymmetric panel ARDL in contrast to the symmetrical scenario, this variant of the panel ARDL, referred to as the nonlinear panel ARDL, allows for an asymmetrical reaction of the global financial shocks to the environmental quality. In other words, in this case, positive and negative changes are not supposed to have the same effect on environmental quality. Thus, the asymmetrical variant of the Equation (3) expressed below:

$$\Delta r_{it} = \beta 0_i + \beta 1_i r_{it-1} + \beta_{2i}^{+} P_{t-1}^{+} + \beta_{2i}^{-} P_{t-1}^{-} + \sum_{j=1}^{N1} \emptyset \delta \Delta rit - j$$

$$+ \sum_{j=0}^{N2} (y_{ij}^{+} \Delta p_{ij}^{+} + y_{ij}^{-} \Delta p_{ij}^{-}) + u_i + e_i \quad (3)$$

where P_t^+ and P_t^- shows the positive and negative financial globalization uncertainty shocks respectively. These shocks are respectively computed as positive and negative partial sum decompositions of financial globalization changes.

4. Empirical results

4.1. Descriptive summary

Table 1 presents a brief description of stats and a list of correlations. The distributions of all variables are greatly skewed, and the kurtosis values suggest that the distributions of the sequence are more clustered with longer tails than the normal distribution form. On the other hand, the correspondence equation indicates that there is a positive link between CO_2 and FGU, RNWE and CO_2, and CO_2 and GDP. Such relationships are merely a reflection of the potential relationship between the entire variables.

Table 1. Descriptive statistics.

	LCO_2	LFGU	LGDP	LRNWE
Mean	1.523	13.253	15.227	16.064
Std. Dev.	1.018	12.805	5.058	2.105
Skewness	−2.271	1.516	1.075	0.503
Kurtosis	7.538	5.025	2.610	1.820
	Correlation Matrix			
	LC02	LFGU	LGDP	LRNWE
LCO_2	1.000			
LFGU	0.279*	1.000		
	(0.000)			
LGDP	0.096*	0.145*	1.000	
	(0.000)	(0.000)		
LRNWE	0.053*	0.231*	0.237*	1.000
	(0.000)	(0.000)	(0.000)	

4.2. Unit root

When using panel data for the multivariate cointegration test and the NARDL panel estimation model, this study carried out a unit root test to assess if the data sets are stationary. The findings of the evaluation are presented in Tables 2, (CIPS and CADF). It can be said that all panel variable series of all parameters are stationary at the first difference, as the resulting p-values are less than 0.05, leading to the dismissal of the null hypothesis that the variable is non-stationary or holds a unit root. Therefore, the panel dataset of this study can be used for panel PMG estimation.

Table 2. Panel unit root test.

Variables	CIPS		CADF	
	At level	At first different	At level	At the first diff
$LC02_{it}$	−1.317	−5.280*	−0.530	−5.372*
	(0.000)	(0.000)	(0.000)	(0.000)
$LFGU_{it}$	−1.853	−5.341*	−0.822	−5.042*
	(0.000)	(0.000)	(0.000)	(0.000)
$LGDP_{it}$	−0.729	−5.214*	−1.084	−6.241*
	(0.000)	(0.000)	(0.000)	(0.000)
$LRNWE_{it}$	−1.680	−5.230*	−0.836*	−5.279*
	(0.000)	(0.000)	(0.004)	(0.000)

*Notes: *, ** and *** Denotes rejection of the null hypothesis at 1% and 5% and 10% significance level.

4.3. Co-integration

We use the cointegration method introduced by Westerlund (2007) to explore the existence of long-term relationships within variables in this study. Westerlund's error-correction approach (2007) is stated as follows:

$$y_t = \gamma_i + \partial_i t + \tau_i D_{it} + x'_{it}\varphi_i + (D_{it}\varphi_{it})'\omega_i + q_{it} \quad (4)$$

$$x_t = x_{it-1} + m_t \quad (5)$$

where $i = 1,\ldots,N$ and $t = 1,\ldots,T$ represent the cross-countries and time period of the data. The k-dimensional vector x_{it} denotes the independent variables and is cited as stochastic. The scalar break dummy represented by D_{it} such that $D_{it} = 1\ if\ t > T_i$ and zero otherwise. Also, γ_i and φ_i denotes the cross-unit specific intercept and slope coefficient before the break, while τ_i and $\omega_i$represent the change in these parameters after the break. m_t And i are represented as an error term with mean zero and independent across. We present the co-integration result using Westerlund panel approach in Table 3 below. Considering the p-values of both the panel and time series of the co-integration result that shows significance at 1 percent, we therefore reject the null hypothesis of no co-integration and accept the alternate hypothesis of long-run relationship among the scrutinized variables.

Table 3. Heterogeneous Co-integration tests.

		with trend		without trend	
	Statistic	Value	*p*-value	Value	*p*-value
Westerlund	G_t	−3.208*	0.000	−3.342*	0.000
	G_a	−12.147*	0.035	−11.521*	0.000
	P_t	−10.075*	0.000	−9.105*	0.000
	P_a	−11.095*	0.000	−18.433*	0.000

*Note: ** and * means the null hypothesis rejection of no cointegration at 5% and 1% levels of significance.

4.4. Estimation

In this section, we present the summary result of the estimation as highlighted in the table 4. In the long run, the positive shock in foreign capital flows exhibit a negative link with CO_2 emissions. Findings implying that further development in capital flows will increase the demand for renewable energy use and subsequently result to improved quality of environment. Such that, a 1-unit increase in financial globalization uncertainty reduces carbon emissions within a range of 42 percent. This is in line with Qamruzzaman and Jianguo (2020); Hübler and Keller (2010); Wang (2009); Ayanwale (2007). Following that, foreign capital flows in developing economy accelerate economic growth with technological advancement, industrialization, infrastructural development, and higher production possibilities for domestic trade expansion, thereby assist effectively to retain energy efficiency and control greenhouse gas emission with the application of advanced technological transfer. On the other hand, negative shocks in foreign capital flows show a negative link with CO_2 emissions. Which implies that there would be a reduction in renewable energy consumption as a result of limiting foreign capital flow, which in turn increase CO_2 emissions (Sinani and Meyer, 2004; Carkovic and Levine, 2005; Lall, 2002). More precisely, a 1% decline in financial globalization uncertainty will increase CO_2 emissions by 22 percent.

Meanwhile, GDP and CO_2 appear to be positively related by 33 percent. This can be substantiated by Rafindadi and Ozturk (2017). As expected, the GDP square turns out to be negative and statistically significance by 25 percent. The findings validate the environmental Kuznet curve hypothesis (Ozturk et al., 2020; Jakada et al., 2020; Kaika and Zervas, 2013). Likewise, the renewable energy indicates a negative and significance relationship towards CO_2 emissions by 39 percent (Crestanello, 2020). Whereas, the result is contrary to the findings of Adedoyin et al. (2020) and Dogan and Ozturk (2017).

Positive and negative shocks of financial globalization uncertainty in the short run, however, increases and decreases the sum of CO_2 emissions depending on the positive or negative decompositions, thereby worsening or improving the environmental efficiency. Whereas, the GDP as well upsurge environmental degradation in the state of short term, while the corresponding GDP square as well as renewable energy shrinks the carbon emissions in the short run.

We also observed in both the long and short run the presence of asymmetric effect running from financial globalization uncertainty to environmental quality of the selected SSA countries. Finding reveal that any observed change in financial globalization uncertainty, would have the definitive significance effect on the quality of environment.

Table 4A. Short run panel NARDL.

Variable	Coefficient	Estd.Error	z-Statistics
$LFGU_{it}^{+}$	−0.502*	0.158	−3.177
$LFGU_{it}^{-}$	−0.324*	0.051	−6.353
$LGDP_{it}$	0.308*	0.085	3.624
$LGDP_{it}^{2}$	−0.402*	0.094	−4.277
$LRNWE_{it}$	−0.345*	0.105	−3.286
ect	−0.621*	0.128	−4.852
Symmetry test			
W_{FGU}	3.432*		
Log Likelihood	279.692		

Table 4B. Long run panel NARDL.

Variable	Coefficient	Estd.Error	t-Statistics
$LFGU_{it}^{+}$	−0.425*	0.102	−4.167
$LFGU_{it}^{-}$	−0.221*	0.042	−5.261
$LGDP_{it}$	0.334*	0.082	4.073
$LGDP_{it}^{2}$	−0.257*	0.068	−3.779
$LRNWE_{it}$	−0.395*	0.098	−4.030
Symmetry test			
W_{FGU}	2.346**		

5. Conclusion

This study evaluates the relationship between financial globalization uncertainty, economic growth, renewable energy and environmental degradation for over the year 1980 to 2019 period for 9 selected sub-Saharan African economies, including Congo Republic, Zimbabwe, Botswana, Kenya, Nigeria, South Africa, Sudan, Togo and Senegal. For the analysis, the research uses nonlinear panel PMG estimation regression model. We are able to validate the environmental Kuznets curve hypothesis which shows that the relationship between productivity growth and the environmental quality goes in favor of the hypothesis, demonstrating that as these countries' economic growth once attain a certain level and increase beyond that point, it then forces a decrease in the environmental degradation.

The study further found asymmetric relationship between financial globalization uncertainty and environmental quality. The result indicates that, while considering the positive shock, as foreign capital flow increases the linkage turns out to be inverse, which means that the corresponding CO_2 emissions goes down. And a possible explanation to this decrease could be linked to the fact that more inflows of foreign capital are usually accompanied by foreign technology, which on the other hand increase the use of renewable energy and subsequently results to a decline in the environmental deterioration. While on the other hand, the negative decomposed variable of the financial globalization uncertainty as well shows a negative relationship, implying that when there is shortage in the foreign capital flows, there is every possibility of having increased deterioration of the environment. This follows that, these sampled countries are characterized with under developed financial system (Ochere et al., 2017), as such efficient resource allocation and the monitoring of the used production machines are usually

ineffective, and that contributes to the use of heavily emitted machines, hence environmental deterioration. Similarly, the p-value of the renewable energy shows that the variable is as well significance and the negative sign of its coefficient indicates an inverse relationship with respect to the environmental degradation. Showing that, as the use of renewable energy increase, the corresponding CO_2 emissions decreases.

6. Policy recommendations

Taking into account the finding that global financial uncertainty may encourage investment in economic activities that generate emission-free goods due to the use of modern technology, therefore, financial institutions should offer priority to credit provision for investment in the use and production of clean and green technologies, maybe by offering lower interest rates on environmental agreements. As these countries continue to diversify their economies with increasing production contributing to high CO_2 emissions, policies should be enacted to motivate more activities in the tertiary sector, such as services and finance, or to encourage the adoption of clean and environmentally friendly technologies by the secondary industry. In essence, to achieve economic and environmental sustainability, green financing is an environmentally sustainable approach. Finally, it has been found that supporting renewable energy provides benefits to the climate. Science and technological advancement are also vital for the production of clean energy sources and associated infrastructure.

7. Limitation of the study and suggestions for future studies

The limitation of the current study is not far from the fact that this research considers only few out of the top leading Sub-Saharan African countries, and this is due to the data availability limitation. But, for future studies, they might consider using more countries with few years' coverage, since data is available for recent years. In addition, other advanced heterogeneous econometrics techniques can be considered, like DCCE, CCE etc.

Conflict of interest

The authors declare no conflict of interest.

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