



CARBON EMISSIONS, RENEWABLE ENERGY AND STOCK MARKET PERFORMANCE IN AFRICA

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Abstract

This study examined the moderating role of renewable energy on the relationship between carbon emission and stock market performance in Africa. The study used secondary data and it is sourced from World Bank Development Indicator database for the period of 2000 to 2022. The descriptive statistics was used to describe the feature of the data and Panel VAR used as the estimating technique. It was found in the short run, that carbon emission and renewable energy have negative and insignificant effect on stock market performance in African. However, the interaction between the carbon emission and renewable energy has negative but insignificant effect on stock market performance. The introduction of the moderating term has reduced the negative effect of carbon emission on stock market performance. However, the joint effect of carbon emission, renewable energy and the interaction between carbon emission and renewable energy can predict the stock market performance in Africa. It was concluded that there is no short run causality or influence running from carbon emission to stock market performance in the selected African countries. Thus, governments must invest in programs that enhance and promote renewable energy in African countries.

Keywords: Carbon emission, Renewable energy, stock market performance, Panel VAR

INTRODUCTION

Understanding the stock market behaviour, especially the price movement and the return generating mechanism is always of great interest not only to the market participants but also academicians. Price movement and return are main tools of predicting the stock market movement and the performance of quoted companies (Zubairu & Oyedeko, 2017). This is because the performance of stock market to economic growth cannot be overemphasized. Thus, the attention of the stock market performance has been a major concern in every economy. In view of this, vast number of factors have been documented as determinants of stock market performance in every economy which include; macroeconomic variables, carbon oxide (CO₂) emission, innovations among others. CO₂ emissions pose a significant hazard to the environment because they fuel climate change. Large volumes of CO₂ are produced by energy production, transportation, and industrial operations. These activities have a negative impact on the economy and environment,

leading to issues with health, climate change, and biodiversity loss (IPCC, 2021). The primary driver of global climate change is mostly attributed to carbon emissions, particularly those of carbon dioxide (CO₂). Carbon dioxide emissions has severely affected sustainable human and social development. Nevertheless, carbon emissions are increasing as a result of rapid urbanization, economic growth, and escalating energy use (International Energy Agency [IEA], 2020). Although Africa contributes just a small share of the global carbon emissions, the consequences of climate change have a disproportionately large impact on the continent. Extreme weather events, changed precipitation patterns, and rising sea levels are already affecting African states, underscoring the urgent need for sustainable development strategies (African Development Bank [AfDB], 2019). Thus, the increasing concentration of carbon dioxide emission in the atmosphere led to global warming which has severe implications for both economic and human development. Thus, carbon dioxide is the primary greenhouse gas behind global warming. Therefore, efforts by international organizations to mitigate the adverse impact of global warming has been a focus on policies to reduce carbon emissions (Acheampong & Boateng, 2019).

The financial sector's expansion such as stock market has been hampered by these impacts, which come at a great cost to economies. Money meant for successful endeavors is instead diverted into adaptation and mitigation and this necessitate the need to lower CO₂ emissions has also led to a rise in expenditures on green technologies and renewable energy sources. Thus, one of the ways to achieve this reduction is through increased consumption of renewable energy and this has been shown to reduce environmental degradation (Li et al., 2024) and simultaneously promote economic growth (Dogan et al., 2020). The importance of renewable energy has source of reducing carbon dioxide emission has attracted the researchers and academia to conduct vast number of studies on how renewable energy mitigate the relationship between carbon dioxide emission and stock market performance. Some of these studies include Ayricay et al. (2024), İnal et al. (2022), Tiwari et al. (2022) among others. However, most of these studies focused on direct relationship among the stock market performance, carbon oxide emission and renewable energy. Also, most of these studies were documented in the developed countries. In view of this, the present studies examine the moderating role of renewable energy on the relationship between carbon emission and stock market performance in Africa.

LITERATURE REVIEW

Carbon Emissions

Carbon emissions are often a byproduct of economic activity, particularly in energy-intensive industries such as mining, manufacturing, and agriculture, which are significant components of many African economies. For example, countries like South Africa and Nigeria, which rely largely on fossil fuels for energy production, have more carbon emissions compared to their less industrialized neighbors (EIA, 2022). These emissions are a double-edged sword: whereas they signal economic activity and growth, they also pose major environmental and health hazards (UNEP, 2021). Investor attitude toward firms is increasingly affected by environmental, social, and governance (ESG) considerations. Companies with high carbon footprints may incur negative investor sentiment due to the perceived risks related to legislative changes, projected carbon levies, and the long-term sustainability of their business models (MSCI, 2023). This mood could impact stock prices and market performance. In Africa, where many nations are still developing, the inclusion of ESG considerations into investment decisions is growing but remains less mature compared to developed markets (PwC, 2022). However, the trend is altering as global investors,

particularly those with assets in African markets, aim for greater transparency and sustainability (World Bank, 2021).

Renewable energy

Renewable energy is becoming the main driver of economic development in Africa, which has important ramifications for stock market performance across the continent. As the world moves toward more sustainable energy sources, integrating renewable energy into Africa's economic environment offers opportunities as well as problems for investors and enterprises. Large amounts of renewable energy are available throughout Africa, including solar, wind, hydro, and geothermal energy. These resources hold significant potential in mitigating the energy problems facing the continent since they reduce reliance on fossil fuels and mitigate the effects of climate change. Morocco, South Africa, and Kenya are a few of the countries that have invested the most in renewable energy initiatives. Africa's renewable energy programs are ambitious and wide-ranging, as seen by the Noor Ouarzazate Solar Complex in Morocco, one of the largest solar projects globally (IRENA, 2022). Infrastructure development for renewable energy is having a major influence on the performance of the African stock market. Businesses that engage in renewable energy projects often exhibit a positive investor mood, which is a sign of the rising demand for sustainable and environmentally favorable investments.

Stock market performance

On the stock market, investors may trade assets like stocks, which represent the ownership of the company issuing the securities. These securities are often offered by large companies, and the guaranteed dividend payments are solely dependent on the success of the issuing company throughout the specified period. According to Ezenduka and Joseph (2020), the stock market serves as a channel for luring in foreign portfolio investments, increasing the amount of money accessible for financial objectives. The writers concluded that financial resources are necessary for progress. Because a strong stock market is often seen as a gauge of a country's overall macroeconomic performance, as Ageme (2020) points out, a stable financial market has been directly associated with economic development. A healthy stock market often promotes intermediate financing, liquidity, and the mobilization of domestic resources in addition to the quantity and quality of investments. Advanced economies have advocated for trade liberalization and the flow of services in debates of international business as a result of changes to their financial systems.

African stock markets have recently shown amazing endurance and development in the face of major hurdles. This growing tendency has been influenced by changes in the economy, technological advancements, and increased investor confidence. For example, the Nigerian Stock Exchange (NGX) and the Nairobi Securities Exchange (NSE) have both taken initiatives to improve market accessibility, openness, and efficiency to attract both local and global investors (World Bank, 2021).

Theoretical review

The Environmental Kuznets Curve (EKC) Theory

Financial development is now without a doubt a crucial component of economic growth since it makes capital accumulation possible via the mobilization and pooling of savings, the improvement of vital information on investment activities, and the efficient deployment of capital. By promoting technical innovation in the energy supply industry to lower emissions, the financial sector also

significantly contributes to the monitoring of energy emissions (Jensen, 1996). This demonstrates how financial prosperity, primarily via the decrease of CO₂ emissions, may significantly aid in the battle against environmental deterioration. Sardosky (2010) claims that financial development shows how money is available for successful ventures and how banks and stock markets may provide finance for enterprises. According to this theory, environmental deterioration decreases as finances improve. Furthermore, financial development commonly initiates research and development (R&D) projects, foreign direct investment (FDI), and the progressive acceleration of economic operations to affect environmental quality via expenditures in environmentally related initiatives (Charfeddine et al., 2018). A strong financial sector lowers borrowing costs, promotes investment, and limits the spread of energy emissions by increasing the efficiency of the energy industry (Tamazian & Rao, 2010). On the other hand, financial growth may degrade environmental quality by promoting industry, which would worsen the environment and increase pollution.

The Porter Hypothesis

The Porter Hypothesis, published in the 1990s by economist Michael Porter, suggests that stringent environmental regulations might promote innovation and increase competitiveness. According to this hypothesis, rather than forcing firms to make expenses, well-crafted environmental rules may encourage innovation that decreases the costs of compliance and even provides net economic gains for them. Businesses and the economy as a whole stand to gain from these advancements if they lead to higher productivity, less waste, and improved resource efficiency (Porter & van der Linde, 1995). The Porter Hypothesis states that companies may gain a competitive advantage via proactive adherence to environmental regulations and investments in green technologies. It is anticipated that companies using renewable energy and sustainable business methods will see increased financial success and investment in the African stock markets. Businesses with excellent environmental performance are often rewarded with increased values and easier access to capital. An increasing number of investors are considering environmental factors while making investing decisions. Investor interest in wind and geothermal energy projects, for example, has increased for Kenyan companies; this indicates that the market is responding favorably to sustainable practices (IFC, 2023).

Empirical Review

Ayricay et al. (2024) examined financial development indicators, the market capitalization of carbon emissions (CO₂), and the use of renewable energy. Panel data cointegration and panel causality analysis. The results showed that market capitalization and carbon emissions have a bidirectional causal link and that the consumption of renewable energy and carbon emissions have a statistically significant negative association. Consequently, improvements in the financial system and energy efficiency will benefit policies that support sustainable growth.

İnal et al. (2022) used a second-generation panel data analysis to examine the link between renewable energy, CO₂ emissions, and growth in oil-producing countries such as Angola, Algeria, Equatorial Guinea, Egypt, Gabon, Congo Republic, Libya, Nigeria, and Sudan from 1990 to 2014. The research used the country-based Kónya panel causality test and the AMG estimator. The neutrality hypothesis was confirmed by the study's results, which indicated that renewable energy had no discernible impact on economic growth. The findings showed that CO₂ emissions have a

notably favorable impact on growth in Egypt, Equatorial Guinea, and Algeria. Therefore, the research suggests that policymakers give renewable energy more consideration.

Emenekwe et al. (2022) examined the relationship between economic growth, carbon dioxide (CO₂) emissions, and financial development (FD) for 37 Sub-Saharan African (SSA) nations between 2000 and 2016. The findings showed that over the long term, CO₂ emissions are reduced by 2.867% for every unit rise in the total FD index. There was a bidirectional causal relationship between FD and CO₂ emissions, according to the Granger causality test. Further investigation into the crucial financial subsectors for low-carbon development indicates that the financial market index, including its efficiency and access characteristics, has a significant impact on reducing CO₂ emissions.

Adebayo et al. (2022) investigated the impacts of the financial expansion of the MINT countries (Mexico, Indonesia, Nigeria, and Turkey) on their CO₂ emissions year over year using historical data covering the years 1969–2019. The full-sample bootstrap non-Granger causality test findings for Mexico and Turkey indicate a one-way causal link between financial development and CO₂ emissions. The findings demonstrated that, during sub-sampled periods, there are significant feedback causal relationships between financial growth and CO₂ emissions in the MINT nations. The paper also points out that throughout time, the effects of financial expansion on emissions in the countries under review both decrease and increase.

Through the application of the quantile regression approach, the unique quantile-on-quantile (QQ) approach, and the nonparametric Granger causality test in quantiles, Awosusi et al. (2022) bridge the gap in the literature by assessing the influence of global trade on consumption-based carbon emissions (CCO₂e) in Uruguay. The model used in the study accounts for other variables, such as renewable energy and financial development, that affect CO₂ emissions. The study revealed that whereas exports, financial development, and renewable energy have negative impacts on CCO₂e in most quantiles, imports have a favorable influence on CCO₂e in all quantiles. The causal interaction from the regressors to CCO₂e is evaluated using the nonparametric Granger causality test in quantiles.

Tiwari et al. (2022) endogenized trade openness, economic growth, and foreign direct investment (FDI) to investigate the effects of stock market development on the usage of renewable energy using a panel dataset including 16 Asian nations from 1990 to 2019. Panel quantile regression (PQR) and it was found that, via a technological impact, increasing trade activity and accelerating economic development may dramatically lower energy use. Furthermore, PQR data show that the growth of equities markets in high-quantile (0.70) countries—those with significantly more established equity markets—encourages renewable energy investments.

The informal sector, often known as the shadow economy, is examined in Nigeria from 1981 to 2019 by Yu et al. (2022) about financial development, economic growth, stock market performance, and environmental damage. The ARDL bound test was used to confirm the long-term relationship between the variables under study. The ARDL long-run results showed that although the shadow economy significantly improves Nigeria's environmental quality, financial development, economic growth, and stock market performance remain the main drivers of the country's carbon emissions. In Nigeria, there is a unidirectional causal relationship between carbon

emissions and trade, financial development, economic growth, stock market performance, and the shadow economy, according to the results of the spectral causality study.

Adebayo and Rjoub (2021) created a theoretical framework to investigate the effects of trade on consumption-based carbon emissions (CCO₂) and take into account the influence of financial development and the use of renewable energy. The study used a variety of second-generation techniques, such as Westerlund cointegration, cross-sectional augmented autoregressive distributed lag (CS-ARDL), and augmented mean group (AMG) tests, to capture the link between CCO₂ emissions and the independent variables. The CS-ARDL's findings demonstrated that although imports and economic growth increase CO₂ emissions, exports and the usage of renewable energy sources lower them.

Habiba et al. (2021) evaluated the effect of stock market and financial institution growth on carbon emissions. Panel econometric approaches are used to do the empirical analysis on the whole sample as well as sub-samples of established and developing countries. The results showed that although carbon emissions in emerging nations rise, they decrease in developed countries and the whole sample when it comes to the stock market development index. The amount of environmental damage across the panels is decreased by the use of renewable energy.

Ekwueme et al.'s (2021) study examined the connection between foreign direct investment, fiscal development, the usage of renewable energy, economic growth, and South Africa's CO₂ emissions (1970 to 2014). The long-term Johansen multivariate cointegration and the long-run coefficient of the vector error correction model test result suggested that there was a statistically significant relationship between the series. Furthermore, there was a robust and positive correlation over an extended period between CO₂ outrush, GDP (economic growth), financial development (FD), and renewable energy.

Awodumi and Adewuyi (2020) looked at how non-renewable energy contributed to economic growth and carbon emissions in the top African oil-producing countries between 1980 and 2015. Non-linear autoregressive distributed lag (NARDL) approach was used it was found that except in Algeria, the per capita consumption of natural gas and petroleum has an unbalanced impact on both economic development and carbon emissions. In Nigeria, a positive shift in the amount of non-renewable energy used slows development but lowers emissions. In the instance of Gabon, rising energy product consumption fosters development and improves the state of the environment. Although these energy sources promote economic development, their use has little effect on Egypt's environmental damage. Although Angola's economy grows as a result of favorable changes in non-renewable energy use, the impact on carbon emissions varies depending on the energy source and time of day.

Odhiambo (2020) examined the dynamic relationship step-by-step between financial growth, economic inequality, and carbon dioxide (CO₂) emissions using data from 39 sub-Saharan African (SSA) countries between 2004 and 2014. The empirical findings showed that financial expansion in SSA nations unconditionally reduces CO₂ emissions. The findings further indicate that the deleterious impacts of financial development on carbon dioxide emissions are not sustainable over certain levels of income inequality. The study's results have important policy implications not just for the SSA but also for emerging countries in general.

Zeqiraj et al. (2020) used the cross-sectional autoregressive distributed lags (CS-ARDL) approach to analyze panel time-series data for European Union member countries spanning the years 1980–2016. The findings show that SMD ultimately blocks LCE. However, long-term LCE is shown to be heavily reliant on technological innovation (TI). The results support the hypothesis that improved LCE results from the production and use of renewable energy. Growth in the stock market encourages LCE via the use of renewable energy and technological innovation. The overall results are difficult to reconcile with the cross-sectional dependence in the sample and the short- and long-run homogeneity criterion.

Maku and Ikpuri (2020) examined issues related to economic growth, carbon emissions, and renewable energy for eight MENA countries from 1990 to 2018. The study used a modified linear Cobb-Douglas production function and the Fully-Modified and Dynamic OLS estimation approaches to investigate the previously described relationship. The panel of the FMOLS result showed that although economic development responds favorably to CO₂ emissions, CO₂ emissions react adversely to renewable energy consumption, in contrast to the positive link between renewable energy consumption and CO₂ emissions indicated by the DOLS.

Amoah et al. (2020) investigated the role of economic freedom and well-being as drivers of renewable energy usage using the proportion of renewable energy in total energy consumption in Africa. To achieve this, the study makes use of panel data from 32 African countries covering the years 1996–2017. It was that the share of renewable energy sources in total energy consumption climbs along with economic well-being in Africa until it finally drops (inverts into a U shape). Second, the decomposed economic freedom indicators show that property rights and tax burdens both reduce the share of renewable energy in total energy consumption. On the other hand, policies that support trade and economic flexibility cause the share of renewable energy sources in total energy consumption to increase.

Rezagholizadeh and colleagues (2020) assessed the impact of several factors on the expansion of renewable energy consumption in Iran, with a special emphasis on the role played by foreign direct investment (FDI) and the advancement of the financial sector, namely the expansion of the stock market. This study used the Auto-Regressive Distributed Lag (ARDL) bounds test approach throughout 1978–2016. The study's findings show a causal relationship between Iran's usage of renewable energy sources, stock market expansion, and foreign direct investment. More specifically, Iran will consume more renewable energy as a result of rising foreign direct investment and stock market growth. On the other hand, using more renewable energy sources will ultimately lead to a significant drop in CO₂ emissions. In addition, increasing FDI and stock market development would raise a country's GDP and, thus, its CO₂ emissions.

Acheampong et al. (2019) used data from 46 sub-Saharan African nations to study the effects of renewable energy and globalization (measured in terms of trade openness and foreign direct investment) on carbon emissions. It did this by using fixed and random impact estimate methodologies. Additionally, it was shown that rising carbon emissions are a result of both population expansion and financial development. The Environmental Kuznets curve concept was supported by the study's findings. To cut carbon emissions, legislation does, however, restrict economic growth and foreign direct investment.

Jebli et al. (2019) looked at the causal relationships between the use of renewable energy, the number of tourists arriving, the trade openness ratio, economic growth, foreign direct investment (FDI), and carbon dioxide (CO₂) emissions for a panel of 22 countries in Central and South America between 1995 and 2010. The empirical findings verify the cointegration of the variables being studied. Short-run Granger causality studies are used to demonstrate unidirectional causalities between renewable energy and CO₂ emissions and commerce, tourism and trade, foreign direct investment, and economic growth and renewable energy and tourism. There is evidence of a reciprocal causal link between tourists, FDI, emissions, and renewable energy over an extended period.

Charfeddine and Kahia (2019) examined the impacts of financial development and renewable energy on economic growth and carbon dioxide (CO₂) emissions using the panel vector autoregressive (PVAR) model. The research also used the impulse response function tool and it was found that financial development and the usage of renewable energy both have little effect and are not very successful at explaining changes in CO₂ emissions and economic growth. These results demonstrate that more needs to be done by the MENA region's renewable energy and financial development sectors to improve environmental quality and promote economic growth.

METHODOLOGY

Expos-facto research design was used and the population of the study constitutes all the countries with the Africa region and sample were drawn through purposive sampling technique. Thus, the sample size of the study comprises of all 10 countries with largest economies in Africa and this constitute South Africa, Egypt, Algeria, Ethiopia, Nigeria, Morocco, Kenya, Angola, Cote d'Ivoire and Tanzania. Data were collected on carbon emission measured as CO₂ emissions kg per 2015 US\$ of GDP, renewable energy measure as Access to clean fuels and technologies for cooking (% of population) and stock market performance measured as Market capitalization of listed domestic companies (% of GDP). The data were gathered from World Bank Data Indicator. The data covered the period of 23 years ranging from 2000 to 2022. The choice of the period of coverage was based on the availability of data and desire to have balanced panel data. The study employed Panel Var and this take a lead from Oyedeko et al (2021). The model was specified as;

$$smp_{it} = \sum_{l=1}^p \alpha_{il}(l)smp_{i,t-l} + \sum_{l=1}^p \beta_{il}(l)cb_{i,t-l} + \sum_{l=1}^p \lambda_{il}(l)re_{i,t-l} + \sum_{l=1}^p \theta_{il}(l)cb*re_{i,t-l} + \varepsilon_{it} + u_{it} \dots 3.1$$

Where: smp represented the stock market performance, cb indicates carbon dioxide, re denotes renewable energy and cb*re shows the interaction between carbon dioxide and renewable energy $\alpha_{ij}(l)$, $\beta_{ij}(l)$, $\lambda_{ij}(l)$ and $\Theta_{ij}(l)$ are the short-term influence coefficient of phase I lag vector. ε_{it} indicates that the system has cross-sectional heterogeneity and μ_{it} is cross-section correlation. The study conducted unit root to showed the order of integration of the variables and this served as the pre-requisite to use ARDL provided the output of the unit root test revealed mixed integration (Oyedeko, et al. 2022; Oyedeko, et al. 2021; Oyedeko, 2019; Zubairu & Oyedeko, 2018; Oyedeko, 2018; Adegoke & Oyedeko, 2018a, b; Zubairu, & Oyedeko, 2017).

RESULT AND DISCUSSION

In this section, results of the descriptive and inferential statistics are presented. The descriptive statistics explains the behaviors of the data and their fitness for empirical analysis; while the inferential give information about the empirical investigation of the relationships between/among

the specified variables. Thus, the descriptive comprises of mean, standard deviation, minimum and maximum values of the variable series and the summary of these statistics are presented in Table 1

Table 1: Descriptive Statistics

Statistics	CB	RE	RECB	SMP
Mean	-0.026867	0.012670	0.017852	0.021644
Median	-0.000449	0.014067	0.022858	0.000000
Maximum	0.254011	0.263158	0.433156	1.982687
Minimum	-1.000000	-1.000000	-1.000000	-1.000000
Std. Dev.	0.159400	0.227222	0.205380	0.340627
Skewness	-4.909018	-3.779734	-3.512239	2.051286
Kurtosis	30.62788	17.37776	18.85205	13.70786
Jarque-Bera	8238.730	2528.712	2881.046	1249.149
Probability	0.000000	0.000000	0.000000	0.000000

Note: CB represent carbon emission, RE represents renewable energ, smp indicates stock market performance and RECB represent the interaction between carbon emission and renewable energy. **Researchers' Compilation, (2024)**

It is remarkable that values are positive in each case except under the carbon emission. This means these variables displayed an increasing tendency through the period of investigation except carbon emission which has increasing and decreasing tendency within the period of investigation. Also the study reveals that the interacting term has the highest standard deviation value and this implies it is the most volatile variable among the variable under consideration. In a different token, the carbon emission is associated with lowest standard deviation value and it denotes that is the least volatile variable among the variable under consideration. The scales of skewness with respect to all variables are negatively skewed except stock market performance and this implies that they have small values over a long period. The values of kurtosis that are larger than 3 and this indicates that they are leptokurtic and therefore, they have tin tail in their distribution pattern, suggesting that there are presence of outliers or large values in the expected future date. More so, the probability values corresponded to Jarque Bera statistics with respect to all the variables are lesser than 5 percent, meaning that the distribution pattern of these variables is not normal. Therefore, in carrying out the inferential analysis of the proposed relationships, the study, first test for stationarity using Harris-Tzavalis technique. The result is reported in Table 2.

Table 3: Harris-Tzavalis Unit Root Test

Variables	HT-Stat	Z-Stat	P-value
re	0.0666	-3.5875	0.0000
cb	-1.4674	-7.9725	0.0000
recb	-1.0362	-7.2983	0.0150
smp	-5.7802	-11.8212	0.0000

Researchers' Compilation, (2024)

It is explicit from the table that Harris-Tzavalis statistics are larger than the critical z statistics and this is supported by the probability values which are respectively less than the alpha value at 5 percent. This suggests that the null hypothesis of panels unit root is rejected with 95 percent confidence. This implies that the panels do not contain unit root and all the variables are stationary at level and the variables can be fitted into models stated in section three for onward estimation.

To estimate the dynamic panel specifications there is need to select their optimal lag time or length. The study accomplishes this, using modified akaike information criterion, modified Schwarz information criterion and modified Hanna Quinn information criterion. The result of the modified information criteria in respect of the specified models shows that the smallest maic, mbic and mqic statistics traced to lag one. In view of this, lag one is selected by the modified akaike information criterion, modified Bayesian information criterion and modified Hanna Quinn information criterion as the optimum lag for the model specified. The panel VAR approach is restricted to lag one. Thus, the study estimated panel VAR using Generalized Method of Moment (GMM) for each models at lag one. Table 3 provides the summarized results.

Table 3: Short Run Effect

Variables	Model 1		Model 2		Model 3	
	Coefficients	Prob.	Coefficients	Prob.	Coefficients	Prob.
Panel A: SMP						
SMP(1)	-.0413817	0.603	.0023703	0.973	-.0100977	0.842
cb(-1)	-.1300747	0.729	-.168016	0.401	.4272443	0.285
re(-1)			-.2000781	0.777	2.237621	0.005
recb(-1)					-.4189845	0.080
Panel B: re						
smp(-1)	.0503562	0.41	.0394237	0.448	.0979614	0.000
re(-1)	13.00867	0.000	4.980491	0.010	-3.482017	0.000
cb(-1)			1.012181	0.000	-.5073544	0.014
recb(-1)					1.353233	0.000
Panel C: cb						
smp(-1)			.0352215	0.223	.0254801	0.314
re(-1)			1.316791	0.047	.8436838	0.194
cb(-1)			.3460137	0.005	-.1296928	0.509
recb(-1)					.2945682	0.022
Panel D: recb						
smp(-1)					.0223854	0.263

re(-1)					-.9604842	0.104
cb(-1)					-.7627395	0.001
recb(-1)					1.214943	0.000

Researchers' Compilation, (2024)

The results in the Table 3 reveals the output of the three model specified in the methodology in which model captures effect of carbon emission on stock market performance among some selected African countries. The model 2 shows the baseline model with a moderating variable as explanatory but excluding the interacting term. The model 3 shows the baseline model with a moderator and the interacting term. Under the model 1, it is explicit that the previous values of the stock market performance and carbon emission have negative and insignificant effect on stock market performance in African. This implies that when previous stock market performance increase by 1 unit, it will reduce the performance of the stock market by .0413817 and when the previous value of carbon emission increase by 1, it will decrease the performance of the stock market by 1300747. Under the model 2, it was revealed that the previous value of stock market performance has positive but insignificant effect on the stock market performance while the carbon emission and renewable energy have negative and insignificant effect on stock market performance. The result of the model 3 showed that the previous value of stock market performance has negative but insignificant effect on stock market performance. The carbon emission has positive but insignificant effect on stock market performance while the renewable energy has positive and significant effect on stock market performance. However, the interaction between the carbon emission and renewable energy has negative but insignificant effect on stock market performance. The introduction of the moderating term has reduced the negative effects of carbon emission and renewable energy on stock market performance. The study equally examines cause and effect; between each pair of the variables in the model using the popular Granger causality technique. The results are shown in Table 4

Table 4: Granger Causality

Variables	Model 1		Model 2		Model 3	
	Coefficients	Prob.	Coefficients	Prob.	Equation \ Excluded	Prob > chi2
Panel A: SMP						
cb	0.120	0.729	0.707	0.401	1.143	0.285
re			0.080	0.777	7.904	0.005
recb					3.067	0.080
All	0.120	0.729	0.755	0.685	9.862	0.020
Panel B: re						
smp	0.169	0.681	0.575	0.448	12.714	0.000

cb			14.513	0.000	6.040	0.014
recb					131.364	0.000
All	0.169	0.681	14.600	0.001	285.263	0.000
Panel C: cb						
smp			1.483	0.223	1.015	0.314
re			3.950	0.047	1.686	0.194
recb					5.268	0.022
All			5.908	0.052	19.884	0.000
Panel D: recb						
smp					1.255	0.263
re					2.644	0.104
Cb					11.478	0.001
ALL					11.710	0.008

Researchers' Compilation, (2024)

The study conducts a Wald test to examine the Granger causality between the pair of variables in the models specification. The test results are summarized in table 5 under the three models. In the first in the first model, it was revealed that carbon emission cannot be used to predict stock market performance in Africa. In addition, the output of the model 2 also shows that carbon emission and renewable energy cannot be used to predict stock market performance in Africa. However, the model 3 show that the carbon emission, renewable energy and the interaction between carbon emission and renewable energy can predict the stock market performance in Africa. Evidence from the results shows that there is no causal relationship between carbon emission and stock market performance. It is also showed that there is no causal relationship between renewable energy and stock market performance. However, it was shown that there is bi-causal relationship between the carbon emission and renewable energy. In addition, it was explicit that the joint effect of stock market performance, renewable energy and carbon emission can be used to predict the interaction between the carbon emission and renewable energy.

Discussion of Result

It was found that in the short run carbon emission and renewable energy have negative and insignificant effect on stock market performance in African. This conform to the finding of Odhiambo (2020) who found positive relationship between the carbon emission and financial development. It was found that carbon emission and renewable energy cannot be used to predict stock market performance in Africa. This contradicts the findings of Emenekwe et al. (2022) who found bi-casual relationship between the carbon emission and financial development. The implication for this is that investor perceive climate regulation as risk which could affect stock

market performance. However, the interaction between the carbon emission and renewable energy has negative but insignificant effect on stock market performance. The introduction of the moderating term has increased the effects of carbon emission and renewable energy on stock market performance. However, the joint effect of carbon emission, renewable energy and the interaction between carbon emission and renewable energy can predict the stock market performance in Africa. The implication for this is that climate-friendly policies need to be made and this could enhance the investors' patronage and boost the stock market performance. Evidence from the results shows that there is no causal relationship between carbon emission and stock market performance. It is also shown that there is no causal relationship between renewable energy and stock market performance. However, it was shown that there is bi-causal relationship between the carbon emission and renewable energy. This supports the findings of Awosusi et al. (2022). In addition, it was explicit that the joint effect of stock market performance, renewable energy and carbon emission can be used to predict the interaction between the carbon emission and renewable energy.

CONCLUSION

In line with the findings, the study concluded that carbon emission and renewable energy have negative and insignificant effect on stock market performance in African in the short run and there is no short run causality or influence running from carbon emission to stock market performance in the selected African countries. However, it was concluded that the introduction of renewable energy as a moderating variable slightly reduced the negative effect of carbon emission on stock market performance among the selected African countries. Thus, governments must invest in programs that enhance and promote renewable energy in African countries. It further recommended that policy makers, investors, business owners etcetera should promote green environment in our communities and this will reduce the carbon emission and promote the stock market performance. One of the limitations of the study is that it only focused on some selected African countries. Thus, other studies can be re-conducted considering the some selected African countries and other countries from developed economy

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