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THE DYNAMIC RELATIONSHIP BETWEEN FOREIGN DIRECT INVESTMENT AND CARBON EMISSIONS IN SOUTHERN AFRICA AND WEST AFRICA REGIONS: THE INTERVENING ROLE OF FINANCIAL DEVELOPMENT

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---ABSTRACT---
The study compares the regions of West and Southern Africa to assess the effect of foreign direct investment and financial development on carbon emissions. Panel data analysis was used in the study to look at the effects in 10 West African countries and 7 Southern African countries. The study employed dynamic panel data estimation techniques, particularly the panel quantile regression method and the generalised method of moment two-step (GMM) method estimation. These techniques were applied to ascertain the extent of the effects and guarantee a trustworthy inference. The results show that financial development has a positive effect on carbon emissions while foreign direct investment has a negative impact on carbon emissions. Furthermore, the study demonstrates that the Environmental Kuznets Curve (EKC) hypothesis exists in Southern Africa. Given the evidence showing that increased domestic credit to private entities is associated with higher carbon emissions, the study recommends that both regions consider green policies.

KEYWORDS: *Foreign direct investment; carbon emissions; Financial development; dynamic panel data GMM estimations; panel quantile regression .*---

1. INTRODUCTION

Climate change and global warming are exerting a growing influence on the well-being of humans, animals, and plants (Zhang and Liu, 2019; Abrahms et al., 2023). Carbon dioxide (CO2) emissions, specifically from greenhouse gases, have been identified as the main driver of global warming (Liu et al., 2016; Lin et al., 2017; Verbič et al., 2022). Behket et al. (2017) found that the worldwide economic growth in 2011 led to a significant increase in carbon emissions, with a rise of 1.4% and reaching a total of 34.5 billion tonnes in 2012. The energy sector in Africa plays a vital role in the economic development and growth of the continent. However, industry participants tend to downplay this fact, resulting in a low recognition score (AEO, 2014). The financial institutions and markets are encouraged to streamline the process of providing finances to the local market to foster the growth of African economies (Berhanu and Azadi, 202; Turkson et al., 2022). Financial development can be measured comprehensively using indicators such as financial efficiency, financial scale development, and financialization. Increasing production levels can lead to improved financial efficiency and the development of larger-scale operations, resulting in increased production of secondary and tertiary goods and more efficient allocation of financial assets (Avadí et al., 2022; Guo et al., 2023). Under this circumstance, financial resources will be accessible for the acquisition of resources used in production, leading to an increase in carbon dioxide emissions (Chen et al., 2021). Furthermore, the focus of financial efficiency enhances the research and development (R&D) efforts and innovation imitation of privately owned businesses, with the goal of reducing the opportunity cost of R&D and enhancing energy efficiency (Linyun and Xiaolu, 2018). According to endogenous growth theory, the accumulation of production factors and technological advancements both drive economic growth (Huang et al., 2017).

A multitude of studies have been carried out using various methodologies in an endeavour to mitigate carbon emissions, with the aim of identifying the most effective approach to counter this imminent danger. This study is motivated by the absence of definitive evidence concerning the connection between foreign direct investment (FDI), financial development and carbon emissions as well as environmental degradation. This lack of evidence is highlighted by the works of Tamazian and Rao (2010), Ozturk and Acaravci (2013), Shahbaz et al. (2016a, 2016b), Bekhet et al. (2017), and Salahuddin et al. (2018). According to Chang (2015), the progress in finance offers various possibilities for promoting renewable energy sources in the battle against carbon emissions. Additionally, in situations where there is a lack of funding in the domestic financial sector, FDI significantly contributes to enhancing economic growth in those nations (Nguyen, 2022; Wang et al., 2023). Moreover, the correlation between foreign direct investment and carbon emissions has been extensively examined, yet a definitive connection between the two has not been established or substantiated by empirical evidence (Jahanger and Usman, 2023; Huang et al., 2023). The Pollution Haven and Factor Endowment hypotheses posit that in countries with lenient environmental regulations, dominant multinational corporations frequently exploit this situation by establishing themselves through foreign direct investment, consequently leading to environmental pollution (Li et al., 2022; Jeetoo & Chinyanga, 2023; Apergis et al., 2023). Consequently, foreign direct investment will lead to a decline in environmental quality. The environmental Kuznets curve hypothesis suggests that as a nation's economy grows, carbon emissions increase initially, but eventually decrease once a certain economic threshold is surpassed.

However, in accordance with the halo effect theory, multinational corporations adhere to global environmental regulations and allocate resources towards eco-friendly technologies through foreign direct investment in the countries where they operate (Ullah et al., 2023; Ponce et al., 2023). Considering these factors prompts the investigation to assess the impact of financial development on carbon emissions. Moreover, the study seeks to make a substantial contribution to the existing body of literature, which serves as evidence for scholars' interpretations and the development of policies. The study aims to compare the regions of West Africa and Southern Africa in order to pinpoint the specific area that is responsible for the rise in carbon emissions due to financial development, foreign direct investment, trade, and economic growth (Apergis et al., 2023). The study employs panel data methodologies, such as panel quantile regression robust method and generalised method of moment, to accomplish this objective. Robust estimations are utilised for dynamic panel data estimation.

The examination of the influence of financial development and foreign direct investment (FDI) on carbon emissions in West and Southern Africa holds significant importance for multiple reasons. It can support the attainment of the United Nations' Sustainable Development Goals by providing information for policies that strike a balance between economic growth and environmental sustainability (Apergis et al., 2023). Gaining comprehension of the correlation among these factors can yield regional-specific knowledge, enabling the creation of specific approaches to alleviate climate change (Appiah et al., 2023; Khattah and Khan, 2023). The policy implications encompass the provision of valuable information to governments and international organisations, enabling them to formulate policies that effectively attract foreign direct investment (FDI) and foster financial development, while simultaneously mitigating adverse environmental externalities (Ullah et al., 2023). Gaining insight into the impact of these factors on carbon emissions can facilitate the attraction of conscientious and sustainable investments, as investors are progressively prioritising environmental, social, and governance (ESG) considerations (Ponce et al., 2023). Research in this field is necessary to uphold economic progress while maintaining environmental sustainability, as mandated by global climate agreements (Appiah et al., 2023). It is crucial to bridge the knowledge gap regarding the precise mechanisms of financial development, foreign direct investment (FDI), and carbon emissions in West and Southern Africa. This is necessary to gain a thorough understanding of the factors that influence carbon emissions and to develop focused interventions.

The study is structured into five distinct sections. Section 1 contains the introduction, section 2 includes the literature review, section 3 introduces the methodology and data description, and section 4 presents the analysis and discussion results.The concluding section, Section 5, encompasses the investigation's conclusion and provides recommendations, ultimately serving as the last section.

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2. LITERATURE REVIEW

2.1 Foreign direct investment and carbon emission nexus

To explore the implications of the pollution haven and factor endowment hypotheses, various investigations have indicated a rise in carbon emissions associated with an influx of foreign direct investment (FDI). Noteworthy instances of these hypotheses manifest in regions such as China, Malaysia, Indonesia, the United States of America, and others (Görg, & Strobl, 2005; Kivyiro, & Arminen, 2014; Hitnam and Borhan, 2012; Tang and Tan, 2015; Lan et al., 2014; Chandran and Tang, 2013, Hanif et al., 2019; Firoj et al., 2023). Conversely, certain studies propose the presence of the halo effect hypothesis in specific areas. These studies contend that foreign direct investment, in those regions, exerts a beneficial impact on carbon emissions by promoting investments in environmentally friendly technologies (Zhu et al., 2016; Jiang et al., 2017; Zhang and Zhou, 2016; Vitenu-Sackey, 2020).

Tang and Tan (2015) examined the interrelationships among energy consumption, carbon dioxide (CO2) emissions, foreign direct investment (FDI), and economic growth in Vietnam from 1976 to 2009. The findings suggest that there is a stable state over a long period of time, in which both income and energy consumption have a direct and positive influence on the release of CO2 emissions. However, income square has a detrimental effect on CO2 emissions. The EKC hypothesis posits a curvilinear relationship between economic growth and CO2 emissions, characterized by an initial increase followed by a decrease. The environmental consequences of foreign direct investment (FDI) in the host country have also been a topic of contention. Previous studies have put forth two contradictory hypotheses: the pollution haven hypothesis and the halo effect hypothesis (Cole & Elliott, 2005; Görg, & Strobl, 2005; Albornoz et al., 2009; Vitenu-Sackey & Acheampong, 2022; Huang et al., 2023). Based on the halo effect hypothesis, the existence of foreign investors will lead to beneficial environmental effects in the host country. This is because multinational companies (MNCs) possess more advanced technology compared to domestic companies, and they are likely to share cleaner technology that is less damaging to the environment. Conversely, the pollution haven hypothesis suggests that multinational corporations (MNCs) will be more inclined to invest in countries with less stringent environmental regulations (Cole & Elliott, 2005; Appiah et al., 2023). If not addressed seriously, this strategy could have detrimental effects on the environment of the host country (Ding et al., 2021; Xinying et al., 2019; Vitenu-Sackey, 2020b; Vitenu-Sackey et al., 2022; Hongli & Vitenu-Sackey, 2019; Apergis et al., 2023). Motivated by inconclusive and divergent findings in existing literature, this study focuses on investigating the influence of financial development on carbon emissions in the Southern Africa and West Africa regions through a comparative analysis.

2.2 Financial development and carbon emission nexus

The advancement of financial systems plays a crucial role in fostering both the expansion and stability of an economy. Existing evidence suggests a reciprocal relationship between financial development and economic growth. To elaborate, as economic growth surges, so does carbon emissions, as noted by Zhang & Cheng (2009), Narayan and Narayan (2010), Borio (2011), Nasir et al. (2015), Vitenu-Sackey (2020), Vitenu-Sackey and Acheampong (2022), Ullah et al. (2023) and Vitenu-Sackey (2023). Zhang (2011) and Luo & Wang (2012) contend that the progress in financial development facilitates increased foreign direct investment and drives economic growth, subsequently intensifying energy consumption; see also Kolstad & Wiig (2011). The efficient evolution of the financial sector generates ample credit, leading to heightened of energy consumption-related products and services. Moreover, the growth of the capital market fosters investments in the energy sector for both production and consumption. It is imperative to consider environmental factors in tandem with financial sector development to prevent degradation, as emphasized by Sadorsky (2010, 2011), Shahbaz et al. (2012a, 2012b, 2013, 2017), and Islam et al. (2013).

The discourse surrounding the connection between financial development and carbon emissions varies. Some studies assert that financial development not only fails to impact carbon emissions negatively but actually aids in their reduction (Daly et al., 2020; Tamazian et al., 2009; Santos et al., 2010; Tamazian and Rao, 2010; Beja (2012); Jalil and Feridun, 2011; Oyedepo, 2012; Reddy, 2013; Abbasi and Riaz, 2016; Zaidi et al., 2019; Dogan and Seker, 2016; Clark et al., 2018; Muhammed et al., 2018; Çetin, et al., 2022). Conversely, another perspective maintains that financial development exerts a positive influence on carbon emissions, leading to an increase (Zhang, 2011; Boutabba, 2014; Shadbaz et al., 2013c, 2016a, 2016b; Omri et al., 2015; Javid and Sherif, 2016; Salahuddin et al., 2018; Acheampong et al., 2020). Alternatively, certain studies posit that the nexus between carbon emissions and financial development is inconsequential, lacking a concrete linkage between the two (Coban and Topcu, 2013; Ozturk and

Acaravci, 2013; Omri et al., 2015; Charfeddine and Khediri, 2016; Lahiani et al. 2021; Bekhet et al., 2017; Churchhill et al., 2018; Wang et al., 2020; Ullah et al., 2023).

2.3 Economic growth and carbon emission nexus

Economic growth serves as a metric to quantify a nation's overall output within a specified timeframe, typically a year, crucial for formulating macroeconomic policies. The computation of economic growth is a characteristic feature of post-World War II capitalist economies (Raworth, 2017; Abrahms et al., 2023). While it is established that economic growth initially leads to an increase in carbon emissions, the Environmental Kuznets Curve (EKC) hypothesis, introduced by Simon Kuznets in the 1950s, posits that, in the long term, economic growth can contribute to a decline in carbon emissions once a certain turning point in the country's economic levels is surpassed. However, a review of existing literature reveals mixed results regarding the universal applicability of the EKC hypothesis (Narayan and Narayan, 2010; Song et al., 2013; Apergis et al., 2017; Atasoy, 2017; Firoj et al., 2023).

Previous research has explored the link between energy usage and economic growth. The topic has generated intense debate among researchers and policymakers. In principle, as the scale of economic activities increases (i.e., with higher levels of economic growth), the demand for energy also increases. Nevertheless, a highly developed nation is also anticipated to employ energy with greater efficiency compared to a less developed nation. Hence, the correlation between the two variables can be either positive or negative. Nevertheless, it is anticipated that the initial channel will exert a significant influence on the correlation between the two variables. Following the influential research conducted by Kraft and Kraft (1978), which investigated the correlation between energy consumption and economic development in the United States, several studies have produced conflicting findings regarding the nature of the relationship between these two variables (Akarca & Long, 1980; Ang, 2008; Zhang & Cheng, 2009).

Contrary to the EKC hypothesis, Oztokcu and Ozdemir (2017) found evidence of an inverted N-shaped relationship between economic growth and carbon emissions, suggesting that continuous economic growth does not necessarily lead to a reduction in carbon emissions. Their analysis, based on panel data from 26 OECD countries, indicated the absence of an EKC. In addition, Al-Mulali and Ozturk (2016) discovered a U-shaped curve or relationship in their study of 26 industrialised nations. They examined the impact of economic growth on carbon emissions. They proposed conducting comprehensive research in underdeveloped nations to determine the validity of the EKC hypothesis in those contexts. Firoj et al. (2023) examines pollution haven hypothesis (PHH) validation and the existence of the environmental Kuznets curve (EKC) hypothesis in Bangladesh. It uses CO2 emissions as a key indicator and considers variables like foreign direct investments, trade openness, financial development, energy consumption, and urbanization. The results suggest that Bangladesh should adopt eco-friendly urbanization planning to mitigate environmental pollution.

3. EMPIRICAL APPROACH

3.1 Data

The study uses panel data from 1995 to 2015 to examine carbon emissions per capita, foreign direct investment, financial development indicators, trade openness, GDP per capita, and financial openness in seven Southern African and ten West African countries. Countries used in this study are West Africa countries: Ghana, Nigeria, Cote d'Ivoire, Togo, Benin, Burkina Faso, Guinea, Senegal, Mali, Niger. Southern Africa countries: South Africa, Botswana, Namibia, Zambia, Mozambique, Malawi, Madagascar. The World Bank's WDI (World Development Indicators Database, 2017) provided the data. The variables' definitions are as follows:

1. Dependent variable: Carbon Emission per Capita---The carbon emissions per capita is a measure of the amount of carbon emissions produced from the use of fossil fuels, calculated by dividing the total emissions by the population, and expressed in metric tonnes.
2. Independent variable: Foreign Direct Investment---Foreign direct investment inflows are expressed as a proportion of the Gross Domestic Product (GDP).
3. Intervening variable: Financial Development---Assessed using a proxy indicator that calculates the amount of credit provided to the private sector within a country, expressed as a percentage of the country's Gross Domestic Product (GDP).
4. Control variable: Gross Domestic Product per Capita---The term "economic growth" refers to the calculation of total GDP divided by the total population in millions of dollars at constant PPP 2011 international.

5. Control variable: Trade Openness---The term "trade openness" refers to the combined value of a country's exports and imports of goods and services, expressed as a percentage of its Gross Domestic Product (GDP).
6. Control variable: Financial Openness---Represents the ratio of net foreign assets to GDP.

All variables underwent a natural logarithmic transformation, except for carbon emissions per capita.

3.2 Methodology
3.2.1 Empirical model

This study aims to assess the validity of the PHH (Pollution Haven Hypothesis) and EKC (Environmental Kuznets Curve) hypotheses by analyzing the influence of foreign direct investment and financial development on CO2 emissions. The following formula represents the general form of the CO2 emissions function:

$$carbon\ emission = f(foreign\ direct\ investment, financial\ development, GDP, trade\ openness, financial\ openness) \quad (1)$$

$$carbone\ emission_{i.t} = a_0 + \beta_1 foreign\ direct\ investment_{it} + \beta_2 gdp\ per\ capita_{it}^2 + \beta_3 financial\ development_{it} + \beta_4 trade\ openness_{it} + \beta_5 financial\ openness_{it} + v_i + \varepsilon_{it} \quad i = 1, \dots\dots, N\ , t = 1, \dots..T_i \quad (2)$$

In equation (2), the symbol "i" denotes the 7 cross-sectional countries in Southern Africa and 10 West African countries, while "t" signifies the time period spanning from 2000 to 2020. The variable "v" represents the panel-level effect, and ε_{it} denotes the independent and identically distributed (i.i.d.) residual term across the entire data sample.
In line with numerous earlier studies such as Narayan and Narayan (2010), Song et al. (2013), Apergis et al. (2017), Atasoy (2017), and Firoj et al. (2023), CO2 emission is designated as the indicator of environmental degradation and used as the dependent variable. The pollution haven hypothesis is supported by the positive correlation between FDI and carbon emissions. Firoj et al. (2023), applied financial development to the EKC hypothesis in a recent study. This study also tries to investigate the EKC in some detail. The EKC hypothesis has traditionally been tested by looking at the non-linear relationship between economic development and CO2 emissions in a variety of literatures. By examining the non-linear relationship between financial development and CO2 emissions, this study explores the EKC hypothesis. Thus, the following is a definition of EKC validity. When the coefficient of financial development is positive and the coefficient of quadratic term of GDP per capita is negative, it means that CO2 emissions are rising during the early stages of financial development until they reach a certain point at which they start to fall. To improve the accuracy of the estimate, four macroeconomic control variables are used: trade openness, financial openness, economic growth, and financial development. The Pollution Haven and Factor Endowment hypotheses posit that in countries with lenient environmental regulations, dominant multinational corporations frequently exploit this situation by establishing themselves through foreign direct investment, consequently leading to environmental pollution (Li et al., 2022; Jeetoo & Chinyanga, 2023; Apergis et al., 2023).

3.2.2 Methods

To reject the null hypothesis, which assumes the presence of a unit root in the variables, the study initially examined the stationarity of the variables using unit root tests. The study employed the tests of Levin et al. (2002), Im et al. (2003), and Fisher-ADF and Fisher PP of Maddala and Wu (1999) to assess cross-section dependence, heterogeneity, and homogeneity. These tests were used to ascertain the presence of a unit root in the variables. To ascertain the enduring correlation between the variables, a panel co-integration test is conducted to assess whether the variables exhibit cointegration. The study incorporates the Johansen Fisher type co-integration test (Zhang and Liu, 2019). After establishing cointegration and rejecting the null hypothesis, the study then employs the dynamic panel data GMM methodology to ascertain the coefficients that represent the impact of the independent variable on the dependent variable.

Due to its reduced susceptibility to heteroskedasticity, the study employed the two-step GMM approach for its estimations, instead of the one-step method. Furthermore, the Sargan test is conducted to validate the precision of the instruments employed in the process. The residuals' autocorrelation is evaluated using the AR(1) and AR(2) tests. The results of the AR(2) test indicate that we cannot reject the hypothesis of no second-order serial correlation among the variables (Lingyun and Xiaolu, 2018). Next, the panel quantile regression methodology is utilized to verify the

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specific quantile levels at which the dependent variable is affected by the independent and control variables. Furthermore, the study aims to ascertain the presence of the Environmental Kuznets curve hypothesis, the Pollution Haven hypothesis, the Halo Effect hypothesis, and the Factor Endowment hypothesis within the sample. The study employs bivariate panel causality to examine homogeneous causality and ascertain the causal direction of the variables. The study conducted by Dumitrescu and Hurlin (2012) examines the causality linkage and direction of the time series data by allowing for heterogeneity in the dynamic models across different cross-sections.

The study utilized two methodologies to assess the influence of financial development on carbon emissions per capita. It employed the Arellano-Bond dynamic panel data estimation, which includes both the Generalized Method of Moments (GMM) and robust estimations. Additionally, it utilised the panel quantile regression methodology to ensure reliable statistical inferences. The study aims to mitigate potential serial correlation issues in the dependent variable by utilizing dynamic GMM and robust panel techniques. Arellano and Bond (1991) advocated for the use of the Generalized Method of Moments (GMM) due to its ability to effectively eliminate autocorrelation of the error term and reduce the correlation between endogenous variables and the error term in a dynamic panel model. This study looks at the factors that influence carbon emissions at various quantile levels in West African and Southern African nations. To improve the robustness of estimations, it also evaluates the effects and unobserved individual heterogeneity of the variables. Equation (3) contains the model for the Arellano and Bond dynamic panel data estimation (Kim et al., 2018).

$$CO2PCit = \sum_{j=1}^{p} a_j \, carbon\ emission_{i.t-j} + \beta_1 foreign\ direct\ investment_{it} + \beta_2 gdp\ per\ capita_{it}^2 + \beta_3 financial\ development_{it} + \beta_4 trade\ openness_{it} + \beta_5 financial\ openness_{it} + v_i + \varepsilon_{it} \quad i = 1, \ldots\ldots, N, t = 1, \ldots..T_i \quad (3)$$

In equation (3), the symbol "i" denotes the 7 cross-sectional countries in Southern Africa and 10 West African countries, while "t" signifies the time period spanning from 2000 to 2020. The variable "v" represents the panel-level effect, and ε_{it} denotes the independent and identically distributed (i.i.d.) residual term across the entire data sample, characterized by a variance of $\sigma_{\varepsilon}^{2},$ j. The parameter "j" corresponds to the time lag, which will be determined through the Arellano-Bond test for serial correlation.

For robustness of the findings, the study employs the panel quantile regression model, as described by Koenker and Basett Jr (1978) and Cheng et al. (2019), to conduct a thorough analysis. The following equation represents the quantile regression model:

$$Q\Delta carbon\ emission_{i.t}\left(\frac{\tau \cdot}{}\right) = a_{1,\tau}\ \Delta foreign\ direct\ investment_{i,t} + a_{2,\tau}\ \Delta gdp\ per\ capita_{it}^2 + a_{3,\tau}\ \Delta financial\ development_{i,t} + a_{4,\tau}\ \Delta trade\ openness_{i,t} + a_{5,\tau}\ \Delta financial\ openness_{i,t} + \beta_i, \quad i = 1, \ldots..N, t = 1, \ldots., T \quad (4)$$

According to Koenker (2004) suggestion, the L_1-norm penalty term must be used to remove unobserved fixed effects from equation (4), since the traditional linear approach finds it impractical for quantile regression. Within this framework, the research employs this methodology to approximate the subsequent model:

$$\underset{a}{argmin} \sum_{k=1}^{k} \sum_{i=1}^{N} \sum_{t=1}^{T} w_{k\rho_{\tau k}} \{\Delta carbon\ emission\_i, t - a_1, \tau foreign\ direct\ investement_{i,t} - a_2, \tau gdp\ per\ capita_{it}^2 - a_3, \tau financial\ development_{i,t} - a_4, \tau trade\ openness_{i,t} - a_5, \tau financial\ openness_{i,t} - \beta_i\} + \mu \sum_{i=1}^{N} |\beta_i| \quad i = 1, \ldots\ldots, N, t = 1, \ldots., T \quad (5)$$

In equation (5), the traditional check function is denoted by $\rho_{\tau\,(y)} = y(\tau - 1_{y<0})$, *and* 1_A *represents the indicator function.* The quantile index is *K*, and the term $\Delta co2pc_{i,t}$ denotes the carbon emissions per person in country *i* at time *t*. Wk is equal to *1/K*, which simultaneously explains the contribution of different quantiles in the estimation and represents the relative weight on the k-th quantile (Koenker, 2004; Zhu et al., 2016; Cheng et al., 2018). Furthermore, μ serves as the tuning parameter and is set to 1 (Lamarche, 2011; Zhu et al., 2011; Cheng et al., 2018).

4. FINDINGS AND DISCUSSION

4.1 Descriptive Statistics

The summary statistics of the six variables that were investigated in this study are presented in Table 1. These statistics include the mean, median, standard deviation, skewness, kurtosis, and data from the Jarque-Bera test. Taking into consideration the outcomes of the skewness, kurtosis, and Jarque-Bera tests, it is clear that the variables do not adhere to a normal distribution. Consequently, the ordinary least squares (OLS) method is not suitable for the investigation that is being carried out.

Table 1 Summary Statistics

	Carbon emissions	Financial development	Foreign direct investment	Financial openness	Trade openness	GDP per capita
Mean	0.718	2.883	1.706	18.860	4.181	7.797
Median	0.279	2.878	1.369	26.391	4.822	7.613
Max.	9.771	5.361	18.918	31.816	9.251	9.954
Min.	0.069	-1.074	-3.187	0.001	-0.618	5.723
Std. Dev.	3.054	2.082	3.144	10.089	2.066	1.853
Skewness	2.114	-0.101	4.183	-1.217	-1.065	1.693
Kurtosis	12.544	4.846	16.862	2.184	6.128	3.757
Jarque-Bera	2375.185***	47.198***	3784.255***	55.7904***	118.6804***	26.999***

Note: *** denotes 1% significance

4.2 Panel unit root tests

Panel unit root tests were performed on the variables that were investigated in this study, and the results are presented in Table 2. Each of the following panel unit root tests were utilized in the research: LLC, IPS, Fisher-ADF, and Fisher-PP. Based on the findings, it was discovered that carbon emissions demonstrated stationarity in accordance with the LLC test, that trade openness demonstrated stationarity based on the LLC test, and that foreign direct investment and financial development demonstrated stationarity across all four tests. In the process of being differentiated, the variables demonstrate stationarity. Since all variables became stationary after the first difference was considered, the alternative hypothesis is accepted with this result. At both the 5% and 1% significance levels, this demonstrates that the null hypothesis, which states that there is a unit root in the variables, is not valid.

4.3 Panel co-integration test

As can be seen in Table 3, the Johansen-Fisher method was utilized to carry out cointegration tests for both West Africa and Southern Africa. After conducting tests of trace and maximum eigenvalue statistics, the findings indicate that the null hypothesis of no co-integration is rejected at a significance level of 1%, thereby confirming the existence of co-integration. This conclusion is reached because of the findings. There is evidence that a relationship of equilibrium exists over the long term between carbon emissions, financial development, foreign direct investment, financial openness, trade openness, and gross domestic product per capita.

Table 2 Panel Unit roots test

	Carbon emissions	Financial development	GDP per capita	Foreign direct investment	Financial openness	Trade openness
level						
LLC	-1.656**	0.380	-1.517	-2.474**	-15.260***	-1.801**
IPS	-0.117	2.340	2.884	-2.193***	-7.683***	-0.510
ADF-Fisher	24.742	20.386	14.689	67.974**	298.778***	31.776
PP-Fisher	28.884	37.290	34.854	86.818***	110.685***	65.844**

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First difference						
LLC	-6.791***	-5.287***	-1.820**	-8.298***	-58.570***	-6.793***
IPS	-7.828***	-7.737***	-5.991***	-11.858***	-19.712***	-8.117***
ADF-Fisher	108.760***	181.872***	85.369***	186.577***	361.582***	118.691***
PP-Fisher	227.865***	211.712***	276.871***	167.700***	242.877***	226.379***

Note: ***, **, * denote 1%, 5% and 10% significance levels.

Table 3 Co-integration test

cointegration test No. of CE(s)	**West Africa**		**Southern Africa**	
	Fisher Statistic Trace test	**Max-eigen test**	**Fisher Statistic Trace test**	**Max-eigen test**
None	478.61***	293.91***	362.20***	220.52***
At most 1	269.70***	213.40***	193.37***	152.37***
At most 2	132.82***	95.42***	91.04***	63.88***
At most 3	46.99***	44.31***	34.56***	36.32***
At most 4	23.24	25.26	13.56	12.76
At most 5	19.54	18.85	19.79	12.79

Note: ***, **, * denote 1%, 5% and 10% significance levels.

4.4 Benchmark results (GMM estimations)

The results of two-step GMM estimations of dynamic panel data are displayed in Table 4. This approach makes use of the exogenous properties and dynamic effect of the dependent variable. Carbon emissions per capita is used as the dependent variable to statistically calculate the time lag for each approach. The evidence suggest that foreign direct investment negatively and significantly impact carbon emission for both regions taking account of the intervening role of financial development—with coefficients of -0.224 for the latter and -0.007 statistically significant. The statistically significant and negative impact of foreign direct investment on carbon emissions in both regions, even after accounting for other confounding variables, indicates that foreign direct investment inflows are not responsible for the rise in emissions in either West Africa or Southern Africa. Furthermore, all sample showed positive and statistically significant coefficients of financial development of 0.264 and 0.110. This demonstrates that as the economies of both regions grow, so do their carbon emissions. In both regions, GDP per capita will rise with carbon emissions according to consistent evidence of a positive relationship between economic growth and emissions (coefficients of 0.909 and 0.437, respectively). While financial and trade openness had a positive impact on carbon emissions, financial openness had a negligible impact in the West African region. The impact of trade openness was found to have a statistically significant coefficient of 0.278 in the Southern Africa region and 0.037 in the West Africa region.

Table 4 Arellano-Bond dynamic panel data estimations

Variables	**Southern Africa**	**West Africa**
	Method	**Method**
	GMM (Two-step)	**GMM (Two-step)**
LN.co2pc	0.181***	-0.452***
L1	(64.10)	(-26.16)
financial development	0.264***	0.110***
	(14.24)	(16.49)
lnforeign direct investment	-0.224***	-0.007***
	(-7.83)	(-6.83)
$Lngdppc^2$	-0.909***	0.437***
	(10.16)	(105.49)
financial openness	0.008***	0.001
	(7.30)	(1.56)
	0.278***	0.037**

lnto		
	(8.14)	(11.71)
constant	-3.441***	-2.923***
	(-17.40)	(-57.36)
Sargan test	18.216	20.830
P-value	0.197	0.972
AR(1)	-2.326**	-3.958***
AR(2)	-1.194	-1.943**
Wald chi2	93973.62***	52978.14***

Note: ***, **, * denote 1%, 5% and 10% significance levels.

4.5 Robustness: panel quantile regression

Here, we present the results of the panel quantile regression analysis for table 5. The table shows that in the Southern African region, the variable GDP per capita has a significant and varied effect. The coefficient increases from the 5th to the 40th quantile, decreases from the 60th to the 70th quantile, increases again in the 80th quantile, decreases in the 90th quantile, and increases in the 95th quantile. Additionally, the data demonstrated a favorable impact on carbon emissions over a period of time, indicating that the increase in GDP per capita is a significant factor in the rise of emissions in the Southern Africa region. The relationships between GDP per capita were consistently positive but asymmetric across all quantiles. However, these relationships were less stable and sporadic when compared to those in the West Africa region. Furthermore, it substantiates the fact that there is a clear and beneficial correlation between economic growth and carbon emissions. Countries experiencing significant fluctuations in carbon emissions per capita are categorized by high quantiles, whereas those with minimal fluctuations are categorized by low quantiles. Countries experiencing significant fluctuations typically exhibit a high GDP per capita, resulting in increased energy consumption. Conversely, countries with minimal fluctuations generally have a low GDP per capita, leading to reduced energy consumption. While the acceptance of the Environmental Kuznets curve (EKC) hypothesis in the Southern Africa region was straightforward, the same cannot be said for the West Africa region. The EKC hypothesis posits that there exists a curvilinear relationship, specifically an inverted U-curve, between the level of economic growth and the amount of carbon emissions.

Table 5 demonstrates a clear and direct correlation between financial development and carbon emissions, as indicated using financial development as a proxy for financial development. The data presented in the table indicates that in Southern Africa, an increase in financial development is linked to a corresponding increase in carbon emissions, with notable asymmetrical patterns. On the other hand, in West Africa, the relationship between financial development and carbon emissions per capita follows a U-shaped trend. In the Southern African region, the financial development increased from the 5th percentile to the 10th percentile, decreased in the 20th percentile, increased from the 40th percentile to the 80th percentile, decreased from the 90th percentile to the 95th percentile, and then decreased again from the 95th percentile to the 99th percentile. Furthermore, in West Africa, the financial development experienced a decline from the fifth to the fiftieth percentile, followed by an upward trend from the sixty-first to the ninety-fifth percentile. In contrast to West Africa, where the impact of financial development on carbon emissions per person is minimal in countries with low GDP per person and significant in countries with high GDP per person, Southern Africa shows a clear relationship between financial development and carbon emissions per person in both low and high GDP per person countries.

Foreign direct investment has a detrimental impact on carbon emissions per person. This impact was particularly noteworthy in the Southern Africa region, ranging from the 50th to the 95th quantile, and in the West Africa region, ranging from the 10th to the 70th quantile (as indicated in table 5). These findings were derived from an analysis of the factor endowment hypothesis, the halo effect hypothesis, and the pollution haven hypothesis in these two regions. Consequently, the study's findings suggest that factor endowment is nonexistent, and instead, both regions exhibit hypotheses related to the halo effect and pollution. Nevertheless, Foreign Direct Investment does not appear to have a significant impact on carbon emissions in either region, indicating that manufacturing does not play a prominent role.

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Trade openness was found to have a negative and statistically significant effect in all quantiles, except for the 30th quantile, where it was not significant in the Southern Africa region. The quantile scores for West African trade openness were all positive. The scores at the 10th, 20th, 40th, 50th, 70th, and 90th quantiles were found to be statistically significant. Upon the analyses, it was concluded that trade openness has a reducing effect on carbon emissions in the southern Africa region but has an increasing effect in the West Africa region. This relationship is characterized by inconsistency and positivity.
Within the lower quantiles, representing countries with low GDP per capita, there is a positive correlation between trade openness and carbon emissions. However, as we move towards the higher quantiles, this correlation gradually becomes negative. Trade openness has a positive impact on carbon emissions per capita in countries with low GDP. During the time spent in the East Africa region, financial openness exhibited a noteworthy and adverse impact from the 5th quantile to the 50th quantile. However, it was found to be insignificant from the 60th quantile to the 80th quantile. Surprisingly, financial openness had a positive and significant effect in the 90th quantile, contradicting the data on financial openness. Nevertheless, there is no discernible relationship between the degree of financial openness and reduced levels of carbon emissions per capita in either of the regions.

4.6 Homogeneous causality test

The homogeneous causality test was employed to validate the growth and bidirectional hypotheses by ascertaining the direction of the relationships between the variables. The variables under consideration were carbon emissions per capita and economic growth, with the former being dependent on the latter. Table 6 demonstrates a clear correlation, both positive and negative, between economic growth and carbon emissions per capita in the Southern Africa region. Modifying a single variable will cause the other variable to shift as well, but in the same direction. A unidirectional connection was present from financial development to foreign direct investment, GDP per capita to financial development, financial development to trade openness, GDP per capita to trade openness, and GDP per capita to financial openness. In the West African region, there is a bidirectional linkage between trade openness and carbon emission, as well as between financial openness and GDP per capita. This means that a change in one variable will cause a corresponding change in the other variable. Furthermore, there exist one-way connections between carbon emission and foreign direct investment, GDP per capita and financial development, financial openness and financial development, trade openness and foreign direct investment, financial openness and foreign direct investment, and trade openness and financial openness. These connections indicate that the initial variable in each pair of linked variables influences the second variable in the pair.

Table 5 Homogeneous causality test

	Southern Africa			West Africa		
Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.	W-Stat.	Zbar-Stat.	Prob.
carbon emission does not homogeneously cause foreign direct investment	2.868	0.364	0.972	3.814	2.819	0.014**
gdp per capita does not homogeneously cause carbon emissions	6.672	5.179	0.005**	4.320	4.575	0.017**
carbon emission does not homogeneously cause gdp per capita	4.847	1.798	0.022**	3.758	0.749	0.387
trade openness does not homogeneously cause carbon emission	5.075	1.699	0.087*	3.982	2.797	0.062*
carbon emission does not homogeneously cause financial openness	3.856	0.910	0.337	4.079	1.821	0.044**
financial development does not homogeneously cause foreign direct investment	5.589	3.423	0.000***	2.079	-0.814	0.783
Gdp per capita does not homogeneously cause financial development	12.281	8.588	0.000***	4.812	2.795	0.005**
trade openness does not homogeneously cause financial development	1.194	-0.896	0.329	3.817	1.823	0.082*

financial development does not homogeneously cause trade openness	8.072	5.491	0.000***	2.511	0.191	0.756
financial openness does not homogeneously cause financial development	2.110	0.671	0.587	5.880	6.998	0.001***
trade openness does not homogeneously cause foreign direct investment	1.377	-0.846	0.753	5.845	4.714	0.001***
financial openness does not homogeneously cause foreign direct investment	1.191	-0.545	0.658	6.256	4.713	0.001***
financial openness does not homogeneously cause gdp per capita	2.478	0.072	0.871	7.924	7.177	0.001***
Gdp per capita does not homogeneously cause financial openness	8.528	5.593	0.001***	7.516	8.387	0.001***
trade openness does not homogeneously cause financial openness	1.865	-0.598	0.656	0.786	-1.966	0.051*

Note: ***, **, * denote 1%, 5% and 10% significance levels.

5. CONCLUSION AND RECOMMENDATION

The research investigated the influence of foreign direct investment and financial development on carbon emissions by conducting a comparative analysis of 10 countries in West Africa and 7 countries in Southern Africa. The research employed a panel study methodology from 2000 to 2020. The study employed panel quantile regression and dynamic panel data GMM/robust methodologies to conduct a robustness analysis on the influence of financial development on carbon emissions in both regions. As per the research conducted by Alex et al. (2019), the results of the analysis confirm that there is a direct and positive relationship between financial development and carbon emissions in West and Southern Africa. The results also indicated that the Environmental Kuznets Curve (EKC) hypothesis holds true in Southern Africa, but not in West Africa. Consequently, when the economic levels exceed a critical threshold, the expansion of the economy in the Southern Africa region will ultimately lead to a reduction in carbon emissions. The results indicate that foreign direct investment has a negligible influence on carbon emissions in West Africa, but it has an adverse impact on carbon emissions in Southern Africa. However, the study acknowledges the validity of the halo effect hypothesis while dismissing the hypotheses regarding factor endowment and pollution in both regions. This could also suggest that the manufacturing sector, known for its heavy reliance on fossil fuels and recognised as the primary contributor to carbon emissions, does not consistently attract foreign direct investment in these two regions. This finding is in support of the existing literature that suggest inconclusive result in relation to the foreign direct investment and carbon emission nexus (see Görg, & Strobl, 2005; Kivyiro, & Arminen, 2014; Hitnam and Borhan, 2012; Tang and Tan, 2015; Lan et al., 2014; Chandran and Tang, 2013, Hanif et al., 2019)

The study suggests implementing stringent regulations to safeguard the environment against carbon emissions. Environmental protection policies aimed at reducing carbon emissions should be accompanied by incentives such as green credits, green investments, and green taxes. Additionally, the private sector should be encouraged to adopt renewable energy sources in the production of goods and services. Given the finding that domestic credit to the private sector contributes to carbon emissions, the implementation of green policies in West Africa and Southern Africa will protect the environment from such emissions. To promote the reduction of carbon emissions, it is advisable for the governments in these regions to gradually establish domestic carbon finance and trading markets. The report proposes the establishment and implementation of environmentally conscious institutions to effectively enforce laws aimed at protecting local environments. In addition, the establishment of credit financial agencies to evaluate low carbon credit policies and oversee the efficiency of credit facilities would be beneficial for the countries. Given the correlation between financial development and carbon emissions, it is imperative that industrialization efforts in Southern and West Africa prioritize the adoption of sustainable and renewable energy sources.

To accurately assess the true impact of Africa's rapid development on carbon emissions, the study proposes conducting comprehensive research across all regions of Africa, considering the inconsistent findings on the relationship between financial development and carbon emissions.

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Table 6 Results of panel quantile regression (Robust)

					Southern Africa						
Variables					**Quantiles**						
	5th	10th	20th	30th	40th	50th	60th	70th	80th	90th	95th
constant	-1.710	-2.509	-0.280	4.471	8.957	6.791	4.364	6.325	5.756	5.872	4.672
	(-2.14)*	(-2.65)**	(-0.43)	(1.11)	(5.78)***	(5.76)***	(6.39)***	(3.70)***	(3.95)***	(3.31)**	(1.47)*
financial development	0.612	0.565	0.505	1.402	1.487	1.934	2.140	2.240	2.121	2.907	2.124
	(6.26)***	(11.09)***	(3.23)***	(3.60)**	(5.97)***	(13.37)***	(14.03)***	(14.42)***	(16.70)***	(12.49)***	(10.28)***
foreign direct investment	-0.027	-0.051	-0.031	-0.094	-0.009	-0.320	-0.401	-0.397	-0.315	-0.392	-0.332
	(-0.16)	(-0.67)	(-0.81)	(-0.23)	(-0.48)	(-2.15)**	(-3.78)***	(-5.41)***	(-4.05)***	(-3.81)**	(-3.65)***
GDP per capita	0.363	0.316	0.453	0.729	1.514	0.991	0.623	0.621	0.743	0.712	0.705
	(6.72)***	(14.25)***	(1.76)*	(2.01)**	(9.82)***	(4.93)***	(3.75)***	(3.89)***	(5.45)***	(5.30)***	(4.34)***
financial openness	0.042	0.012	0.091	0.045	0.014	0.092	-0.043	0.004	-0.018	-0.031	0.050
	(1.93)	(2.07)**	(0.71)	(1.72)	(1.47)*	(0.37)	(-0.19)	(0.08)	(-0.92)	(-0.34)	(0.31)
Trade openness	-0.581	-0.694	-0.856	-3.084	-5.192	-4.717	-3.717	-3.131	-3.305	-3.329	-3.421
	(-2.84)**	(-4.48)***	(-0.47)	(-1.08)*	(-7.76)***	(-6.19)***	(-6.73)***	(-7.73)***	(-8.62)***	(-6.73)***	(-4.31)***

Note: ***, **, * denote 1%, 5% and 10% significance levels.

Variables				West Africa	Quantiles						
	5th	10th	20th	30th	40th	50th	60th	70th	80th	90th	95th
Intercept	-2.173	-2.316	-1.781	-1.672	-1.486	-1.499	-1.989	-1.944	-1.613	-1.793	-1.857
	(-13.01)***	(-6.83)***	(-7.92)***	(-27.44)***	(-24.78)***	(-15.43)***	(-15.94)***	(-11.86)***	(-8.22)***	(-7.65)***	(-3.19)**
financial development	-0.089	-0.088	-0.036	-0.056	0.006	0.047	0.058	0.080	0.173	0.196	0.199
	(-16.44)***	(-5.95)***	(-1.51)	(-1.95)*	(0.52)	(3.91)**	(2.99)***	(6.99)***	(6.67)***	(5.86)***	(2.42)**
foreign direct investment	-0.014	-0.017	0.011	0.063	0.011	-0.010	-0.012	-0.015	-0.012	0.000	-0.017
	(-2.92)**	(-1.17)	(0.17)	(0.48)	(0.22)	(-0.11)	(-0.66)	(-2.74)**	(-0.36)	(0.13)	(-0.25)
GDP per capita	0.533	0.23	0.626	0.559	0.764	0.722	0.161	0.215	0.201	0.231	0.391
	(41.47)***	(16.11)***	(11.72)***	(23.15)***	(24.95)***	(10.15)***	(16.19)***	(11.21)***	(8.18)***	(11.43)***	(7.19)***
financial openness	-0.017	-0.016	-0.014	-0.014	-0.013	-0.012	-0.011	-0.011	0.011	0.013	0.014
	(-1.89)**	(-4.65)***	(-7.14)***	(-10.18)***	(-5.35)***	(-2.92)**	(-1.31)	(-0.19)	(0.40)	(2.87)**	(1.21)
Trade openness	0.075	0.047	0.013	0.094	0.064	0.093	0.024	0.084	-0.017	-0.185	-0.515
	(3.86)***	(2.91)***	(1.41)	(2.03)**	(2.20)**	(1.93)	(1.67)*	(1.95)	(-1.94)	(-3.40)**	(-1.95)

Note: ***, **, * denote 1%, 5% and 10% significance levels.