Financial Development, Carbon Financing and Carbon Emission in Sub-Saharan African Countries

Onome Omena ADOGBO
PG/MGS1917587

DEPARTMENT OF FINANCE
FACULTY OF MANAGEMENT SCIENCES
UNIVERSITY OF BENIN
BENIN CITY, NIGERIA.

SEPTEMBER, 2025

Financial Development, Carbon Financing and Carbon Emission in Sub-Saharan African Countries

Onome Omena ADOGBO
PG/MGS1917587

BEING A DISSERTATION WRITTEN IN THE DEPARTMENT OF FINANCE, FACULTY OF MANAGEMENT SCIENCES AND SUBMITTED TO THE COLLEGE OF POSTGRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY (Ph.D) IN FINANCE, UNIVERSITY OF BENIN, BENIN CITY, NIGERIA.

SEPTEMBER, 2025

DECLARATION

I, **Onome Omena ADOGBO,** a Doctor of Philosophy (Ph.D.) candidate of the Department of Finance, Faculty of Management Sciences, University of Benin, Benin City, Nigeria, do hereby declare that this dissertation is entirely my research work. The work embodied in this dissertation has not been submitted in candidature for any degree and it is not concurrently being submitted for any other degree. All references from other works have been duly acknowledged.

______________________ ______________________

Onome Omena ADOGBO **Date**

(PG/MGS 1917587)

CERTIFICATION OF DISSERTATION

We certify that this dissertation written by **Onome Omena ADOGBO** is adequate in scope and quality in partial fulfilment of the requirements for the award of Doctor of Philosophy (Ph.D.) Finance in the Department of Finance, Faculty of Management Sciences, University of Benin, Benin City, Nigeria.

______________________________ ______________________________

Prof. (Mrs.) E. I. Evbayiro-Osagie **Date**
(Chief Supervisor)

______________________________ ______________________________

Prof. E. J. Idolor **Date**
(Co- Supervisor)

______________________________ ______________________________

Dr. A. O. Izekor **Date**
(Head of Department)

CERTIFICATION OF DISSERTATION ON ANTI-PLAGIARISM

We the undersigned attest and declare that the Dissertation of **Onome Omena ADOGBO** titled: "**Financial Development, Carbon Financing and Carbon Emissions in Sub-Saharan African Countries**" has successfully passed the anti-plagiarism test and does not violate any copyright regulation as at 23rd May, 2025.

____________________________ ____________________________

Prof. (Mrs.) E. I. Evbayiro-Osagie **Date**
(Chief Supervisor)

____________________________ ____________________________

Prof. E. J. Idolor **Date**
(Co- Supervisor)

____________________________ ____________________________

Dr. A. O. Izekor **Date**
(Head of Department)

ATTESTATION

We the undersigned attest that **Onome Omena ADOGBO** has successfully carried out all the corrections as recommended by the external and internal examiners in her dissertation titled: "**Financial Development, Carbon Financing and Carbon Emissions in Sub-Saharan African Countries**".

Prof. (Mrs.) E. I. Evbayiro-Osagie **Date**
(Chief Supervisor)

Prof. E. J. Idolor **Date**
(Co- Supervisor)

Dr. A. O. Izekor **Date**
(Head of Department)

Dr. O. Aigbovo **Date**
(Internal Examiner)

DEDICATION

This dissertation is dedicated to the Almighty God, who spur me to embark on this academic journey and whose mercy, grace and unending love overwhelmed and sustained me during the course of my studies in University of Benin, Benin City.

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to God for his grace, strength, inspiration, provisions and favour throughout the course of my study and to everyone who has contributed to the successful completion of my course work and this Dissertation in my academic pursuit. This milestone would not have been possible without the unwaving support and guidance of my Chief Supervisor Prof. (Mrs.) E. I. Evbayiro-Osagie and Co-supervisor Prof. E. J. Idolor for their priceless comments, corrections and contributions to this Dissertation despite their busy schedule. God bless you.

My deep appreciation goes to my Head of Department Dr. A. O. Izekor, Prof. S. O. Igbinosa, Prof. Emeretus Bob Osazee, and Ven. Prof. I. O. Osamwonyi who thoroughly nurtured me in the course of my study. And my discussants at various stages in the course of my defence Dr. J. Obayagbona, Prof. M.G. Ajao and other academic and non-academic staff in the Department for all your immeasurable support during the course of this programme amongst whom are Dr. Omorokunwa .G.O, Dr. O. Aigbovo, Dr. O. Osifo, Dr. O.F. Ogieva, Dr. E.I. Igbinovia, Mr. Efosa and others too numerous to mention.

I am very grateful to my husband Engr. Arute Akunoma for his financial support and filling the gap throughout the course of my study. You are a good husband and my kids Erezioghene, Ogheneyole and Ogheneyoma Akunoma, for being focused while I was struggling with academic work. I love you guys. To my late Daddy Prof. M.P. Adogbo whose academic prowess and excellences was a great motivation to me, my late beloved mummy Mrs R.O. Adogbo who was my pillar of strength, thanks for your prayers, financial support and encouragement, unfortunately you have gone to be with the Lord before my graduation, may your souls continue to rest in the bossom of the Lord amen. I also want to appreciate my aunt

Patience Isiboge and my siblings especially Obuks Ray Adogbo for your financial supports. I'm very grateful to you all.

Finally, my Ph.D. colleagues; Amenze Airhiavbere, Victor Chiedu Mahonwu, Adelegan Oluyomi, Omehe Raphael, Micah Elujekor, Ayo Olagunji, Tijani Umoru who walked this journey with me, your encouragement and insight were invaluable and my friends Dr. Osayande Monday, Dr. (Mrs) Inoni Rita, Mrs Ferguson Linda for your prayers and encouragement. God bless you all

TABLE OF CONTENTS

CONTENTS **PAGE**

CHAPTER TWO: LITERATURE REVIEW

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This study examined the effect of financial development and carbon financing on carbon emission in Sub-Sahara Africa. The study adopted stratified sampling technique. The population of the study is the Sub-Sahara African Countries, while the sample of the study was made up of seven (7) Sub-Saharan African Countries.

The study employed secondary data collected from World Bank Development Indicators (WBDI) and the International Monetary Fund (IMF) Financial Structure Database. In order to present a robust outcome in the relationships, the pooled mean group (PMG) technique which is an autoregressive distributed lags (ARDL) approach to panel data estimation was adopted for the empirical analysis. However, the presence of cross-sectional dependence in the panel data ensured that the panel correlated standard errors (PCSE) technique was used for robustness tests. Data used for the study is annual panel data for seven SSA countries with developing capital markets covering the period of 2000 to 2023.

The findings from the study revealed that financial development exerts divergent effects on carbon emissions in Sub-Sahara African Countries. In particular, the study found that the level of financial liquidity supports sustainability by significantly reducing carbon emissions in SSA, private credit allocation still favours high-emission activities in the region. Thus, it shown that increased credit penetration significantly increases carbon emission. The economic implication is that, financial deepening mitigates climate degradation in SSA economies while the standard of credit and formal funds allocation is highly inefficient in addressing the climate crisis in SSA. The study recommends that, financial flows in SSA countries should be directed toward sustainable sectors while disincentivising carbon-intensive financing either through regulations or explicit incentive measure.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Global warming, environmental degradation and carbon emission are currently the three most crucial issues of global concern which have posed serious threat to human existence and have also attracted serious attention from governments, policy makers, academia and environmental experts over the past three decades (Habiba & Xinbang, 2022). This have been severally attributed to the increasing emission of greenhouse gases of which carbon dioxide (CO_2) emissions are the most harmful due to the negative impact on human health and the environment (Habiba & Xinbang, 2022). According to Stocker, Qin, Plattner, Tignor, Allen, Boschung, Nauels, Xia, Bex, and Midgley (2014), about 76.7 percent of total greenhouse gas emissions are attributed to CO_2 emissions as a result of the attendant increases in the use of conventional energy sources like those of coal, gas, and crude oil. Corroborating the above, the International Energy Agency (2019) reported that polluting energy sources accounted for about 68 percent of the world CO_2 emissions. For this reason, the Brundtland Commission report of 1987 declared the accumulation of CO_2 as one of the environmental threats to the planet (Global Environmental Outlook 4 (GEO4), 2007); occurring naturally through photosynthesis, animal grazing, respiration of humans and rock weathering, and its highest concentration is human-induced through combustion, the use of fossil fuels for energy as well as deforestation and land-use practices (Goodland & Anhang, 2009; GEO4, 2007).

Carbon emissions also known as carbon footprints, is strongly connoted with the earlier concept of ecological footprint advocated by Rees (1992), which has gained considerable attention and publicity over the years. “It represents a standard measure of human demands for natural resources on planet earth that is now beyond its ecological capacity to cope with and regenerate, resulting in serious depletion of the natural resources thereby creating wastes for the earth to absorb in form of different shades of greenhouse gases (GHG) emissions in waters, air and on land; and it could also be generated from agricultural activities, energy consumption, transportation, use of water, foods among others” (Gao, Liu & Wang, 2013 p.2-3). It is also an estimation of the aggregate CO_2 emissions directly or indirectly caused by an activity or accumulated through the product life cycle; where carbon dioxide is not only one of the greenhouse gases (GHG) but its most vital component, followed by CH4 and N2O (Gui, Ren, Zhao, Zhou, Xie, Xu & Zhu, 2019; Syafrudin, Zaman, Budihardjo, Yumaroh, Gita & Lantip, 2020).

Carbon credits also known as carbon financing provide a means of leveraging new private and public investment in projects to reduce GHG emissions in developing countries. According to Food and Agriculture Organization of the United Nations (FAO, 2010) and United Nations High Commissioner for Refugees (UNHCR, 2021), the need to reduce/minimize global warming and carbon footprint emissions has become a global concern which has led to the introduction of different forms of financing strategies like green credit, international emissions trading (ET), clean development mechanisms (CDM), joint implementation (JI), green climate funds, climate investment funds among others (Gillenwater & Seres, 2011). Thus, those of CDM which generates certified emission reduction credits (CERs) equivalent to one tone of CO_2 is seen as the closest to Kyoto Protocol (third conference of the parties (COP 3) to the united nations framework conventions on climate change), and is more appropriate for resolving and minimizing the attendant impact of carbon emissions in developing countries (Africa inclusive) (FAO, 2010).

Mobilizing sufficient finance is critical if the Sub-Saharan African countries are to effectively mitigate and adapt to the impact of climate change. According to the Intergovernmental Panel on Climate Change (IPCC) (2018), the investment required for the world to stay within a 1.5°C warming scenario ranges from $1.6 trillion to $3.8 trillion in low-carbon energy and infrastructure annually out to 2050, with an average of $3 trillion–$3.5 trillion annually (IPCC 2018; Heubaum & Volz, 2022). Thus, carbon credits/financing can play a major role in closing the existing funding gap, while transiting the SSA region into a low-carbon footing by 2050, because a carbon price seeks to address the external costs of carbon emissions caused through their effect on global warming (Heubaum & Volz, 2022). That is to say, "a carbon credit increases the cost of carbon dioxide (CO_2) emissions over time and shifts the cost of the damage caused back to the heaviest polluters; and if set at an adequately high level, carbon prices will make carbon-intensive energy sources, such as coal, unprofitable (Heubaum & Volz, 2022)".

In financial sector, liquidity plays a vital role in addressing environmental concerns thus financial liquidity is the ease with which assets or securities can be quickly converted into cash without significant loss of value, directly influences investments in sustainable projects. High liquidity in the financial sector can enhance firms' ability to fund cleaner technologies and support emissions reduction initiatives. However, it can also facilitate quick access to capital for high-emission industries, potentially exacerbating environmental degradation (Shen et al., 2021). In SSA, where balancing environmental priorities with financial constraints is critical, financial liquidity has been identified as an enabler of green investments, especially in economies with limited resources (Mensah et al., 2023).

Similarly, metrics such as Bank Credit to GDP reflect the allocation of financial resources to private-sector development. When directed toward environmentally conscious sectors, bank credit can support green innovations and renewable energy investments, thereby reducing emissions (Abudu et al., 2022). However, credit heavily skewed toward carbon-intensive industries may amplify emissions, complicating efforts to build sustainable financial systems in SSA (Heubaum & Volz, 2022). Policymakers in the region must therefore consider frameworks for credit allocation that minimize environmental footprints while fostering economic development. Furthermore, Stock market activities, represented by metrics like the value of stock traded and stocks market turnover, also significantly influence environmental outcomes. Active trading in environmentally sustainable sectors can attract investments in green projects and drive emissions reductions (Rahman & Alam, 2022). Conversely, heavy trading in carbon-intensive industries could reinforce high emission levels, particularly in SSA, where extractive industries often dominate (Eryılmaz et al., 2015).

Financial development has many dimensions, such as financial depth, financial liquidity, financial efficiency, financial structure, financial stability, and financial inclusion (Cihak et al., 2021). Financial development is part of the private sector development strategy to stimulate economic growth by minimizing carbon emissions and poverty level as well as checkmating "overall costs" incurred in the financial system. This process of reducing costs of acquiring information, enforcing contracts, and executing transactions results in the emergence of financial contracts, intermediaries, and markets (Eryılmaz, Bakır & Mercan, 2015). Therefore, the improvement of the financial sector (especially the banks and stock market activities) can also affect CO_2 emissions by stimulating different developmental activities such as inverted u-shaped effect, increased consumption, allocation of financial resources, foreign direct investment inflows, trade openness (Rahman & Alam, 2022). If financial development is identified to be a significant variable affecting CO_2 emissions, this will have important implications on climate change and sustainable development policies (Shen et al., 2021; Wang et al., 2020; Rahman & Alam, 2022). The Brundtland Commission (1987) report suggested that humanity has the ability to make development sustainable and this further demonstrated that a link exist between environmental quality and development in general Global Environmental Outlook 4 (GEO4 2007:6). Financial development matters for cleaner CO_2 environment due to its ability to provide effective financial services to eco-friendly programs that would reduce CO_2 emissions in developing countries (Tamazian, Piñeiro & Vadlamannati, 2009; Onanuga, 2017).

Several positive efforts such as (de-carbonize buildings and construction, developing a renewable energy system and enable low-carbon alternatives in the transportation sector) towards climate change and transition into a green economy are evident in the Sub-Saharan Africa and it has gained serious acceptance because of its proposed proactive response to addressing and preventing the climate, food and economic crises that the world has been facing over the years (UN DESA et al., 2013). According to Onanuga (2017), "Africa's acceptance of the green economy dates back to 2009 when the third African Ministerial Conference on Finance for Development, in Kigali, Rwanda, called for the creation of an enabling environment that embraces low-carbon development and supports the green economy transition (Nhamo & Nhamo, 2014)". There is no doubt that carbon emission and financial development are critical and evolving issues that have attracted so much global attention till date and this nexus needed to be effectively investigated in the Sub-Sahara African Countries. Therefore, this study is an attempt to contribute to this debate by empirically investigating the relationship between financial development, carbon financing and carbon emission in the Sub-Saharan Africa (SSA) countries, and to see the extent to which the rate of carbon emission has impacted financial development. (Climate Action Tracker, 2023).

1.2 Statement of the Research Problem

The growing cases of environmental pollution in Sub-Saharan Africa over the past decades, following industrialization, has become imperative and a matter of urgency policy concern to examine the relationship between financial development, carbon financing and carbon emissions in Sub-Saharan Africa. This issue became particularly important due to challenges of environmental degradation. Increase environmental degradation in terms of carbon emission and other greenhouse gases, if unabated will impose great threat to human survival in terms of sustainable development.

More specifically, the problem is that financial development and carbon financing if effectively combined and utilized, are expected to reduce overall level of carbon emissions. Sub-Saharan African (SSA) governments have increasingly recognized the importance of integrating financial development and carbon financing to combat climate change and reduce carbon emissions. Many countries in the region have adopted national climate strategies aligned with global frameworks such as the Paris Agreement and the UN Sustainable Development Goals. Kenya, for example, launched the Green Bond Program in 2019, enabling the issuance of tax-exempt green bonds to finance sustainable infrastructure and renewable energy projects. Similarly, Nigeria became the first African country to issue a sovereign green bond in 2017, using the proceeds to fund projects in afforestation, solar energy, and transportation. South Africa, one of the continent's largest carbon emitters, has implemented a Carbon Tax Act since 2019, which places a price on carbon emissions to incentivize cleaner industrial practices. These countries are also working to reform their financial systems by embedding environmental, social, and governance (ESG) standards to guide investment and lending decisions toward more sustainable outcomes. Beyond financial instruments, SSA governments have engaged in carbon financing initiatives through mechanisms like the Clean Development Mechanism (CDM) and voluntary carbon markets. Ethiopia, through its Climate Resilient Green Economy (CRGE) Strategy, has attracted international carbon finance to support afforestation and off-grid renewable energy. Rwanda launched a national Green Fund (FONERWA) that blends domestic and international finance to support low-carbon development projects, ranging from green urban planning to climate-smart agriculture. Ghana is participating in the World Bank's Forest Carbon Partnership Facility to reduce emissions from deforestation and forest degradation (REDD+), while Mozambique has implemented a jurisdictional REDD+ program in its Zambézia province. These efforts are further supported by partnerships with the Green Climate Fund (GCF), the African Development Bank (AfDB), and bilateral donors. Through such integrated strategies, SSA countries are leveraging financial innovation and carbon financing to not only reduce emissions but also to stimulate inclusive and sustainable economic development.

However, despite the various efforts and initiatives by respective SSA governments in this regard, it is still not clear the extent to which these two factors (financial development and carbon financing) have been able to minimize carbon emissions in the Sub-Saharan African Countries. This is one of the main rationales for this current study. The role of financial development and carbon financing in the reduction of aggregate carbon emissions globally have been empirically investigated by some authors across the globe. However, the submission by these authors showed conflicting findings with regard to how financial development and carbon financing affect carbon emissions. For instance, the findings of Tamazian, Pinẽiro and Vadlamannati (2009); Scholtens and Veldhuisa (2015); Onanuga (2017); and Tsaurai (2019) indicated significant positive relationship between financial development and carbon emissions: but those of Tamazian and Rao (2010); Al-Mulali, Tang and Ozturk (2015); Ntarmah, Kong and Manu (2021); Rahman and Alam (2022); Xuezhou, Manu and Akowuah (2022); Nwabueze, Abner, Victor, Nwude, Samuel and Udo (2023) revealed a significant negative relationship between financial development and carbon emissions in their respective studies. Now, given this mixed finding, this study is carried out in order to ascertain the extent to which financial development and carbon financing have affected carbon emissions in the Sub-Saharan African countries.

Although several empirical studies have been carried out on financial development, carbon financing and carbon emission nexus in the Sub-Saharan African Countries; and majority of the empirical evidences like Yang, Tan, Chu and Chen (2022), Sarkodie and Strezov (2019), Rahman and Alam (2022), Bekhet, Matar and Yasmin (2017), Koçak and Şarkgüneşi (2018) among others, are found in China, the US and other parts of the advanced countries outside Africa. However, there are several studies in this area in the SSA with conflicting findings of significant positive and negative relationship between financial development and carbon emissions include those of Ssali, Du, Mensah and Hongo (2019), Aluko and Obalade (2020), Ntarmah, Kong and Manu (2021), and Chireshe (2021). Therefore, with the current quest to reduce global warming through the services of the financial sectors by way of credit facilities to encourage greenhouse gas, it is expedient that the role of financial development in carbon emissions reduction be empirically examined in the SSA countries in order to see the extent to which it has affect carbon emissions reduction.

The idea of carbon credits also known as carbon financing is to provide a means of leveraging new private and public investment in projects to reduce Green House Gas (GHG)emissions in developing countries (FAO, 2010; UNHCR, 2021); and the need to reduce/minimize global warming and carbon footprint has become a global concern which has led to the introduction of different forms of financing strategies like green credit, international emissions trading (IET), clean development mechanisms (CDM), joint implementation (JI), green climate funds, climate investment funds among others (Gillenwater & Seres, 2011). Till date, apart from the Kyoto Protocol, Brundtland Commission (1987) report, the 2021 Climate Change Act and the African Green Economy Partnership (AGEP), to the best of the researcher's knowledge, only a few empirical studies in the SSA has been carried out on how the implementation of these several green credits/financing mechanisms such as certified emission reduction (CER) unit and climate investment funds (CIF) (which are already available) have impacted carbon emissions in the SSA. The truth is that, while it is one thing to establish policies, commissions and credit units, it is another thing to further find out how each of these established processes have impacted global warming and carbon footprint emissions. This therefore is the point of departure of this studies from others, and seeks to contribute to the literature on carbon credits/financing and carbon emissions nexus by focusing on the SSA in order to find out the extent to which certified emission reduction (CER) unit and climate investment funds (CIF) have impacted carbon emissions.

1.3 Research Questions

The study seeks to provide answers to the following specific research questions:

(i) what is the relationship between financial liquidity and carbon emission (measured by total greenhouse gas emissions (GHG)) in the Sub-Sahara Africa?

(ii) what is the effect of banks' credits to GDP on carbon emission in Sub-Sahara Africa?

(iii) to what extent does the value of stock traded affect carbon emission in the Sub-Sahara Africa?

(iv) how does stock market turnover influence carbon emission in the Sub-Sahara Africa?

(v) to what extent does certified emission reduction (CER) unit affect carbon emission in the Sub-Sahara Africa?

(vi) what is the relationship between climate investment funds (CIF) and carbon emission in the Sub-Sahara Africa?

1.4 Objectives of the Study

The main objective of this study is to examine the effect of financial development and carbon financing on carbon emission in Sub-Sahara Africa. However, the specific objectives are to:

(i) examine the relationship between financial liquidity and carbon emission (measured by total greenhouse gas emissions (GHG)) in the Sub-Sahara Africa;

(ii) ascertain the effect of banks' credits to GDP on carbon emission in the Sub-Sahara Africa;

(iii) investigate the effect of value of stocks traded on carbon emission in the Sub-Sahara Africa;

(iv) determine the relationship between stock market turnover and carbon emission in the Sub-Sahara Africa;

(v) examine the effect of certified emission reduction (CER) unit on carbon emission in the Sub-Sahara Africa; and

(vi) ascertain the effect of climate investment funds (CIF) on carbon emission in the Sub-Sahara Africa.

1.5 Hypotheses of the Study

The following specific hypotheses stated in their null forms will be tested in the study:

(i) there is no significant relationship between financial liquidity and carbon emission (measured by total greenhouse gas emissions (GHG)) in the Sub-Sahara Africa.

(ii) banks' credit to GDP does not significantly affect carbon emission in the Sub-Sahara Africa.

(iii) value of stock traded has no significant effect on carbon emission in the Sub-Sahara Africa.

(iv) there is no significant relationship between stock market turnover and carbon emission in the Sub-Sahara Africa.

(v) certified emission reduction (CER) unit has no significant relationship with carbon emission in the Sub-Sahara Africa.

(vi) there is no significant relationship between climate investment funds (CIF) and carbon emission in the Sub-Sahara Africa.

1.6 Scope of the Study

This study is on the effect of financial development and carbon financing on carbon emission in Sub-Sahara African Countries. Geographically, the study scope is limited to the Sub-Saharan Africa. The UN Development Programme (2023) classified the SSA countries as 49 African countries, (See Appendix). The choice of the SSA is predicated on the fact that, Africa contributes just 4 percent of global carbon emissions despite being the continent that will suffer the most from climate change (AJLabs, 2023), due to heavy dependence on fossil fuel coupled with the slow pace of adapting and implementing renewable energy and greenhouse gas.

However, the SSA region is one of the top recipients of dedicated carbon finance initiatives; where South Africa ($488 million), Mozambique ($30million), the Democratic Republic of the Congo and Tanzania (with $25 million each). Thus, South Africa is the largest recipient of carbon finance in SSA, and the host of the 17th United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties, Box 1(COP1) considers the particular role that carbon finance has played in that country's efforts to address climate change (Heinrich Böll Foundation South Africa, 2011). Beside, several poorer countries seem to have been neglected by international carbon finance support. For example, Uganda and Chad received less than $0.5 million over the last three years from dedicated climate funds monitored by CFU. Hence, the large gap between funding approved and funding spent on projects suggests serious bottlenecks in program implementation in the SSA region. (Climate Action Tracker, 2023)

From notable sources; AFDB (2023) and GCF (2023), the key observations showed that between 1990–2000**,** Carbon finance flows were minimal, primarily driven by early adaptation projects and bilateral aid. Meanwhile, between 2001–2023: Funding surged with the establishment of global funds like the GCF and CIF, as well as regional mechanisms through the AFDB. The major recipients include Countries with higher vulnerability to climate impacts or advanced green policies, such as South Africa, Kenya, and Ethiopia, received significant funds.

Hence for this study, the relevant data for the study will cover a period of twenty four (24) years (2000 to 2023) for seven (7) SSA countries Such as Cote d' Ivoire, Ghana, Kenya, Mauritius, Namibia, Nigeria, and South Africa. These countries were chosen because they were regarded as the highest emitters of carbon dioxide (CO_2) in 2023 (Sasu, 2023), and they were also found to have relevant data for the period of the analysis. This period is chosen because it takes into account the series of climate change conventions, actions and resolutions in Africa and in the SSA. For instance, the 2021 Climate Change Act, the government was expected to evolve a carbon tax and carbon trading. Also, the meeting of stakeholders from six African countries (Burkina Faso, Ghana, Kenya, Mauritius, South Africa and Uganda) held on March 23rd – 24th 2017 at Accra Ghana at a Regional Policy Dialogue centered on the Switch Africa Green project: as well as the Nigeria adoption of new Methane Guidelines in January 2023 that include mandatory measures for oil and gas companies, such as leak detection, to reduce methane emissions from the oil and gas sector. All these will help us to have a meaningful evaluation of the effect of financial development and carbon financing on carbon emission in Sub-Sahara African Countries.

1.7 Significance of the Study

Given, the fact that researches on the area of financial development, carbon financing and carbon emission in SSA have been carried out by several researchers, this study intent to fill the gap with a view to contributing to knowledge. A major contribution of this study is the combining of financial development and carbon financing to ascertain their effect on carbon emissions reduction thus, this study is significant in the following respect:

Firstly, with respect to foreign investors, it will assist them to identify some of the sensitive CO_2 emissions assets characteristics in the SSA region, and by so doing; they will be able to minimize associated investment or portfolio risks. For instance, firms with disproportionately high CO_2 emissions are often exposed to carbon pricing risk and other regulatory interventions to limit emissions; firms that relied mostly on fossil energy are also more exposed to technology risk from lower-cost renewable energy. Therefore, rational investors will seek compensation for holding the stocks of disproportionately high CO_2 emitters and the associated higher carbon risk they can be exposed to.

Secondly, the outcome of this study will help government and relevant policy makers in the sub-region in formulating appropriate policies and programs that will help to reduce overall greenhouse emissions gases beyond business as usual, thereby promote overall environmental quality improvement. This can be achieved by initiating and encouraging environmentally sustainable projects such as production of energy from renewable sources like solar, wind, biogas, clean transportation that involves lower greenhouse gas emission; energy efficient projects like green building; waste management that includes recycling, efficient disposal and conversion to energy, among others.

Thirdly, the introduction of carbon finance in the form of clean development mechanism (CDM) credit, which is also known as 'certified emission reduction units (CERs) and climate funds accessed from climate investment funds, is an important determinant of carbon footprints reduction in Sub- Saharan Africa.

Fourthly, the outcome of this study will provide relevant data and information to non-governmental agencies and the United Nation's agencies, which are interested in supporting reduction in carbon footprint, to identify the shortfall between carbon finance needs and actual carbon finances invested in the Sub-Saharan Africa region, as well as countries that need assistance to improve their environment and achieve the goals of carbon footprint reduction.

Lastly, the outcome of this study will not only expand the frontier of knowledge of researchers, academia and students of finance and allied disciplines but will also provide them the platform for relevant data and information to carry out further studies in the same area or related areas of interest.

1.8 Limitations of the Study

One of the obvious limitations of the study involving financial development is the precise measurement of data, which varied across empirical literature. As it stands, there is no consensus on an acceptable proxy for financial development. For instance, in the literature, different measures were used to measure financial development. Some studies used financial liquidity as measure of financial development; others either used banks credits to private sector, bank loans to GDP, value of stock traded and stock market turnover ratio. However, in order to overcome this problem, this study will employ four of these variables as proxies for financial development. This procedure was also utilized by Zhao and Yang (2020), Yuam, Liao and Wang (2022), Yang, Tan, Chu and Chen (2022), Odhiambo (2020), and Xu et al. (2021).

Also, in terms of method of data analysis, this study therefore utilized the autoregressive distributed lags (ARDL)-based estimation framework. However, for the panel data, the ARDL framework crystalizes into the Pooled Mean Group (PMG) analysis technique which also generates both short run and long run estimates within a panel data framework. The specific advantage of the ARDL- based estimation model is the ability to analyze both short-run and long-run dynamics, and they can handle variables with different orders of integration. The problem of ARDL is that, it does not address cross sectional dependence. But it is useful for determining the dynamic relationship among the variables. To address the above problem, the study used the panel correlated standard errors (PCSE) estimates to account for the cross-sectional dependent and estimate long –run relationships.

1.9 Operational Definition of Terms

In this sub-section, certain terms which are used in this study but are not so common in the field of finance are explained in details in order to provide a clear understanding of such terms.

Clean Development Mechanism (CDM) -this is a project based mechanism specifically pertaining to developing countries, which helps Annex 1 Parties (developed countries) to invest in projects that can reduce or remove carbon emissions in non-Annex 1 countries (developing countries) by earning credits called certified emission reduction (CERs) units from the projects as a result of the emission-reduction or removal of that project.

Climate Change- climate change is the changing weather patterns and temperature due to global warming. It can also be climate changes arising from either direct or indirect human activities that negatively impact on modern global atmospheric composition in addition to natural variability in climate over a certain period of time. Sometimes, the terms global warming and climate change are interchangeably used.

Green Climate Funds (GCF) -is a United Nations- backed fund that helps developing countries adapt to and mitigate climate change. Green climate fund is a fund for carbon finance that seeks to promote the paradigm shift towards low- emission and climate resilient development pathways by providing support to developing countries to limit or reduce their greenhouse gas emissions.

Global Warming (GW) -it is the gradual rise in the earth's temperature due to the trapped radiation called global warming. This phenomenon is a major threat to the ecosystem and can lead to climate change.

Greenhouse Gases (GHG) - greenhouse gases are the gases in the atmosphere that raise the surface temperature of planets such as the earth. What distinguishes them from other gases is that they absorb the wave lengths of radiation that a planet emits, resulting in the greenhouse effect.

Joint Implementation (JI)- this is a project based mechanism by which a developed country can invest in a project that has the capacity to reduce or remove carbon emissions in another developed country and receive credits called emission reductions (CERs) units from the projects as a result of the emission reduction or removal of that project.

Kyoto Protocol- this was an agreement to limit and reduce a qualified amount of emissions within a specific commitment period in order to attain sustainable development, which was adopted at the third conference of the parties to the United Nations Framework Convention on Climate Change (COP3) in Kyoto, Japan on the 11th of December1997, but came into force on the 16th of February, 2005.

United Nations Framework Convention on Climate Change (UNFCCC) - is a treaty that aims to prevent human interference with the climate system by reducing greenhouse gas emissions. This convention was adopted by the United Nations on the 9th of May, 1992 in New York.

United Nations High Commissioner for Refugees (UNHCR) -is a United Nations agency mandated to aid and protect refugees, forcibly displaced communities and stateless people, and to assist in their voluntary repatriation, local integration or resettlement to a third country.

Metric Tonnes- a metric ton, also known as tonne, is a unit of mass that is equal to 1,000 kilograms

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter is on the review of relevant literature on financial development, carbon financing and carbon emissions in Sub-Sahara African Countries and other parts of the globe. The chapter is specifically reviewed under three main headings which are conceptual review, theoretical review and empirical review.

2.2 Conceptual Review

2.2.1 Concept of Carbon Emissions

According to Lawinsider (2023), "carbon emissions means carbon dioxide (CO_2) emission when fossil fuels are burned in vehicles, buildings, industrial processes and so on; and CO_2 is one of the Greenhouse Gases (GHGs) identified by the Kyoto Protocol, which warm the atmosphere; and there are six greenhouse gases, which include carbon dioxide, methane, nitrous oxide and fluorocarbons, often referred to together as 'carbon dioxide equivalent' (CO_2e), but Nitrous oxide from diesel and petrol combustion is a potent greenhouse gas and also prejudicial to human health when inhaled" Thus, carbon emissions' is often used as a catch-all term to include both carbon dioxide and other greenhouse gases. Carbon dioxide (CO_2) is a colourless, odourless and non-poisonous gas formed by combustion of carbon and in the respiration of living organisms and is considered a greenhouse gas, and emissions means the release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time; hence, carbon dioxide emissions or CO_2 emissions are emissions stemming from the burning of fossil fuels and the manufacture of cement; they include carbon dioxide produced during consumption of solid, liquid, and gas fuels as well as gas flaring (Eurostat Statistic Explained, 2023).

According to Merriam Webster (2023), carbon emissions also known as greenhouse gas is a term used to define various gaseous compounds like carbon dioxide and methane that absorb infrared radiation and trap heat in the atmosphere, which contributes to what scientists refer to as the greenhouse effect. However, Kilinc-Ata (2022) sees it as the release of carbon into the atmosphere. Because greenhouse gas emissions are usually calculated in carbon dioxide equivalents, they are often referred to as "carbon emissions" in any discussion of global warming or greenhouse gas impacts. But from the point of view of Cambridge Dictionary.org (2023), it is the process of expelling carbon dioxide from automobiles and factories into the atmosphere that has a detrimental impact on the sustainability of the environment.

Furthermore, carbon emissions are the carbon dioxide equivalent of harmful gasses transferred to the atmosphere, enabling the greenhouse gas effect which is believed to cause the global warming (Aydogan, 2021). It is also defined by Chummun (2023) as the pollution that gets injected into the environment from carbon monoxide and carbon dioxide and is generally caused by automobiles or vehicles. While Unhelkar and Lan (2011) stated that it is the production of Carbon dioxide (CO_2) affected by human activity including the processes during the manufacturing of products.

Increasingly, researchers are emphasizing that carbon emissions, while primarily driven by the combustion of fossil fuels, are significantly impacted by economic activity and technological advancements. For instance, Xu, Zhu, and He (2022) found that carbon emissions are strongly correlated with industrialization and urbanization, as rising demand for energy-intensive goods and transportation fuels directly increases CO_2 levels. These emissions are not only a major driver of climate change but also have adverse effects on air quality and public health (Aydogan, 2021). The multidimensional nature of carbon emissions—from the burning of fossil fuels in industrial sectors to transportation and energy use—presents ongoing challenges for reducing global carbon footprints (Chummun, 2023; Unhelkar & Lan, 2011).

In the context of carbon emissions reduction, financial mechanisms such as carbon pricing, emissions trading, and green financing have been explored as viable solutions to mitigate environmental impacts while fostering sustainable development. According to Heubaum and Volz (2022), carbon financing, which includes green bonds and carbon credits, incentivizes investments in projects designed to cut emissions, especially in developing regions. This aligns with findings by Mensah et al. (2023), who argue that increased financial liquidity can bolster investments in cleaner technologies, particularly in Sub-Saharan Africa, where economic limitations hinder environmental progress. Meanwhile, studies by Abudu et al. (2022) suggest that targeted bank credits can also drive green innovation by facilitating investments in low-carbon sectors, such as renewable energy. Furthermore, Rahman and Alam (2022) note that active trading in environmentally conscious sectors within the stock market can attract capital towards sustainable projects, thus support emission reduction goals. Such financial interventions underscore the importance of aligning economic development with environmental objectives to reduce carbon footprints and achieve sustainable growth.

Table 1: Recent CO_2 Emissions Profile for the SSA Countries

Country	CO_2 Emissions (Mt)	Emissions per Capita (t)
Angola	13.96	0.4
Ethiopia	16.29	0.1
Ghana	18.50	0.6
Kenya	21.50	0.4
Senegal	9.70	0.6
South Africa	452.92	7.7
Sudan	14.26	0.3
Nigeria	130.98	0.5
Côte d'Ivoire	14.49	0.48
Namibia	4.29	1.48
Mauritius	4.28	3.36

Source: World Bank Data, 2023

This table reflects the countries' absolute CO_2 emissions in million tons (Mt) and per capita emissions (t) as of the most recent reliable data from sources such as Our World in Data and the World Bank. South Africa notably emits the highest CO_2 both overall and per capita, attributed largely to its coal-intensive energy sector. Nigeria follows as the second-largest emitter in absolute terms, though its emissions per capita are relatively lower, showing significant disparities in CO_2 output across these African nations. Hence, this data provides context for understanding CO_2 emission trends in the region, relevant for discussions on environmental policies and sustainable practices.

2.2.2 Concept of Carbon Financing

Carbon financing is a branch of environmental finance that covers financial tools such as carbon emission trading to reduce the impact of greenhouse gases (GHG) on the environment by giving carbon emissions a price. However, in a bid to effectively deter the use of fossil fuels, like coal, fuel oil and gasoline, which are very vital to minimizing the buildup of heat-trapping greenhouse gases in the atmosphere (Parry, 2021), carbon credits/ financing mechanisms has been introduced to provide for all forms of GHG emissions incentives to reduce energy use and shift to cleaner fuels which is an essential price signal for redirecting new investment to clean technologies (Gillenwater & Seres, 2011; UNHCR, 2021). Some of the financing mechanisms over the years include green credit, international emissions trading (ET), clean development mechanisms (CDM), joint implementation (JI), green climate funds and climate investment funds among others. Given the report of UNFCCC (2021c) on registered projects globally, 3412 projects with over 710 million certified emission reduction units (CERs) were issued in 72 countries, in which 69 projects were cited in Africa and out of these, Sub-Saharan African Countries (SSA) were recipient to about 52 projects. As at the end of 2021, about 8055CDM active projects activities are around the globe generating approximately 8357706372 initial CERs; and out of the 7850 registered project globally, only 225 of them are cited in Africa amounting to about 2.867% of the total project activities.

Hence, carbon financing has emerged as a crucial tool for incentivizing reductions in greenhouse gas (GHG) emissions, with particular emphasis on trading mechanisms and financial tools that assign a monetary value to carbon emissions (Parry, 2021). This approach aims to shift investments from carbon-intensive energy sources to clean technologies by providing price signals that encourage reduced fossil fuel reliance and increased energy efficiency (Gillenwater & Seres, 2011). The developments of carbon financing mechanisms, such as carbon credits, international emissions trading, and clean development mechanisms (CDM), reflects a global commitment to leveraging finance for climate action. These financial instruments have demonstrated considerable success, particularly in incentivizing the private sector to invest in emission-reducing projects, often using certified emission reduction (CER) units to quantify impact. According to Jaforullah and King (2017), the concept of carbon credits allows both developed and developing countries to offset emissions while promoting sustainable investments, particularly in emerging economies where cleaner technologies are gaining traction.

Despite its promise, carbon financing faces significant challenges in Sub-Saharan Africa (SSA), where project implementation remains limited relative to other regions. According to the United Nations Framework Convention on Climate Change (UNFCCC) (2021c), as of 2021, only 2.867% of CDM projects globally were located in Africa, with even fewer projects in SSA. Researchers argue that the low uptake in SSA may stem from financial, infrastructural, and policy limitations that restrict access to carbon markets (Lütken, 2019). Moreover, the scarcity of carbon-financing projects in SSA countries has implications for regional climate change mitigation efforts, as these countries are particularly vulnerable to climate impacts and could benefit from financial tools that foster low-carbon development (UNFCCC, 2021). Addressing these barriers through policy reforms, increased private sector involvement, and international support could potentially accelerate the integration of carbon financing in SSA, leading to broader participation in global carbon markets and a more substantial contribution to emission reductions (Rafique & Rehman, 2022)..

2.2.3 Concept of Financial Development

Financial development refers to the fulfillment of the functions of the financial system in the best manner by eliminating the market distortions (Eryigit & Eryigit, 2015). But, Bahtiyar (2015) defined it as the degree of improvement in financial markets. Both concerning the size and quality of financial markets. It is about overcoming “costs” incurred in the financial system, and this process of reducing the costs of acquiring information, enforcing contracts, and making transactions resulted in the emergence of financial contracts, markets, and intermediaries (Nuru, & Gereziher, 2021). Thus, it involves the establishment and expansion of institutions, instruments and markets that support this investment and growth process (Altay & Topcu, 2017). Eryigit and Dulgeroglu (2015) defined financial development as “the developments in the size, efficiency and stability of and access to the financial system, where financial size is the relative size of the financial system in the economy, efficiency is the meeting of necessary requirements (elimination of market distortions, competitive markets, accessible information) for the provision of highest quality financial services at the lowest cost possible; financial stability is the resistance of the financial system against shocks; and financial access, the possibility of the users of financial services to access them without facing price and non-price impediments”. According to Zhao (2021), “financial development is the continuous improvement of financial efficiency brought by the expansion of financial transaction scale and the process of financial industry upgrading, reflected in the elimination of financial repression and the improvement of financial structure, the innovation of financial instruments and the diversification of financial institutions to adapt to economic development”.

In a related study by Abdullahi, Tsauni and Tabash (2022), financial development is the development of financial institutions, financial markets, and financial instruments. It involves funding of entrepreneurial activity and innovations. However, Çetin, Ecevit, Seker and Günaydin (2015) see it as some improvements in producing information about possible investments and allocating capital, monitoring firms and exerting corporate governance, trading, diversification, and management of risk, mobilization and pooling of savings, easing the exchange of goods and services. These financial functions affect savings and investment decisions, and technological innovations and hence economic growth.

Thus, financial development is widely recognized as a cornerstone of economic growth, enhancing the efficiency of resource allocation and supporting investment in key sectors. According to Beck, Levine, and Loayza (2000), financial development strengthens economic productivity by improving the allocation of capital and providing mechanisms for risk management and savings mobilization. In well-functioning financial systems, capital flows more freely to sectors with high growth potential, thus driving innovation and productivity improvements across the economy. Rajan and Zingales (2003) highlight that financial development reduces the cost of external finance to firms, allowing easier access to funds for enterprises, which in turn drives technological progress and entrepreneurial growth. This aligns with Demirgüç-Kunt and Maksimovic's (1998) findings that firms in countries with more developed financial systems are more likely to expand because they can acquire capital at lower costs, enhancing both sectorial and macroeconomic growth. Consequently, financial development fosters not only immediate growth but also the resilience of economies to external shocks, which is particularly important for developing regions.

In terms of environmental sustainability, financial development also plays a key role by influencing how capital is allocated towards low-carbon and environmentally sustainable investments. Zhao, Cheng, and Liu (2022) argue that a robust financial system can provide funding for eco-friendly projects, such as renewable energy and sustainable agriculture, contributing to lower greenhouse gas emissions and fostering sustainable economic growth. Similarly, Tamazian, Chousa, and Vadlamannati (2009) found that financial development positively affects environmental quality by promoting investment in cleaner technology and green energy. This connection between finance and environmental sustainability is echoed by Acheampong (2019), who notes that effective financial systems in developing countries can incentivize firms to adopt sustainable practices by providing access to green financing and credit for eco-friendly projects. As such, financial development not only catalyzes economic growth but can also help address critical environmental challenges by guiding investment towards sustainable industries, which is crucial for the long-term economic stability of Sub-Saharan Africa and other emerging regions.

2.2.4 Measurement of Financial Development

A good measurement of financial development is crucial to assess the development of the financial sector and understand the impact of financial development on economic growth and poverty reduction. In practice, however, it is difficult to measure financial development as it is a vast concept and has several dimensions. Empirical work done so far is usually based on standard quantitative indicators available for a long time series for a broad range of countries. For instance, ratio of financial institutions' assets to GDP, ratio of liquid liabilities to GDP, and ratio of deposits to GDP. Nevertheless, as the financial sector of a country comprises a variety of financial institutions, markets, and products, these measures are rough estimation and do not capture all aspects of financial development. The World Bank's Global Financial Development Database developed a comprehensive yet relatively simple conceptual 4x2 framework to measure financial development around the world. This framework identifies four sets of proxy variables characterizing a well-functioning financial system: financial depth, access, efficiency, and stability. These four dimensions are then measured for the two major components in the financial sector, namely the financial institutions and financial markets:

	Financial Institutions	Financial Markets
Depth	• Private Sector Credit to GDP • Financial Institutions' asset to GDP • M2 to GDP • Deposits to GDP • Gross value added of the financial sector to GDP	• Stock market capitalization and outstanding domestic private debt securities to GDP • Private Debt securities to GDP • Public Debt Securities to GDP • International Debt Securities to GDP • Stock Market Capitalization to GDP • Stocks traded to GDP
Access	• Accounts per thousand adults(commercial banks) • Branches per 100,000	• Percent of market capitalization outside of top 10 largest companies • Percent of value traded outside of top 10 traded

	adults (commercial banks) • % of people with a bank account (from user survey) • % of firms with line of credit (all firms) • % of firms with line of credit (small firms)	companies • Government bond yields (3 month and 10 years) • Ratio of domestic to total debt securities • Ratio of private to total debt securities (domestic) • Ratio of new corporate bond issues to GDP
Efficiency	• Net interest margin • Lending-deposits spread • Non-interest income to total income • Overhead costs (% of total assets) • Profitability (return on assets, return on	• Turnover ratio for stock market • Price synchronicity (co-movement) • Private information trading • Price impact • Liquidity/transaction costs • Quoted bid-ask spread for government bonds

	equity) • Boone indicator (or Herfindahl or H-statistics)	• Turnover of bonds (private, public) on securities exchange • Settlement efficiency
Stability	• Z-score • Capital adequacy ratios • Asset quality ratios • Liquidity ratios • Others (net foreign exchange position to capital etc.)	• Turnover ratio for stock market • Price synchronicity (co-movement) • Private information trading • Price impact • Liquidity/transaction costs • Quoted bid-ask spread for government bonds • Turnover of bonds (private, public) on securities exchange • Settlement efficiency

Source: The World Bank's Global Financial Development Database (2023)

2.2.5 Importance of Financial Sector Development

A large body of evidence suggests that financial sector development plays a huge role in economic development. It promotes economic growth through capital accumulation and technological progress by increasing the savings rate, mobilizing and pooling savings, producing information about investment, facilitating and encouraging the inflows of foreign capital, as well as optimizing the allocation of capital. Countries with better-developed financial systems tend to grow faster over long periods of time, and a large body of evidence suggests that this effect is causal: financial development is not simply an outcome of economic growth; it contributes to this growth. (Cihak et al., 2021)

Additionally, it reduces poverty and inequality by broadening access to finance to the poor and vulnerable groups, facilitating risk management by reducing their vulnerability to shocks, and increasing investment and productivity that result in higher income generation. Financial sector development can help with the growth of small and medium sized enterprises (SMEs) by providing them with access to finance. SMEs are typically labor intensive and create more jobs than do large firms. They play a major role in economic development particularly in emerging economies. Financial sector development goes beyond just having financial intermediaries and infrastructures in place. It entails having robust policies for regulation and supervision of all the important entities. (Wang et al, 2020). The global financial crisis underscored the disastrous consequences of weak financial sector policies. The financial crisis has illustrated the potentially disastrous consequences of weak financial sector policies for financial development and their impact on the economic outcomes. Finance matters for development both when it functions well and when it malfunctions. The crisis has challenged conventional thinking in financial sector policies and has led to much debate on how best to achieve sustainable development.

Reassessing financial sector policies after the crisis in an important step in informing this process. (Abudu et al. 2022)

2.2.6 Financial Development and Carbon Emissions

The debate on the nexus between financial development and carbon dioxide emissions are often traceable to the works of Lanoie, Laplante and Roy (1998); Dasgupta, Laplante and Mamingi (1998). According to them, financial development related factors are very crucial to attaining environmental quality; and that in an egalitarian society where there exists an active financial system, it will be able to provide sufficient motivation that will enable firms in developing countries to reduce their CO_2 emissions. For example, with proper information among capital markets participants and communities, there will be reasonable deliberations to encourage and informed the firms the importance of adopting a more pollution controlled framework/platform, thereby bringing about a good response. This development can provide appropriate financial motivation like enhanced company's market capitalization; regulations would bring about inverse attitude towards the capital markets and communities (Onanuga, 2017).

Furthermore, financial institutions may also be required to give priority to firms by way of incentives when they are looking for funding for the procurement of cleaner technologies and low-emission driven investments through a reduction in administrative charges and interest on loans (Shahbaz, Solarin & Mahmood, 2012b). The sector can also facilitate foreign capital inflows and offer to hedge for financially weak firms that would like to procure environmental-friendly types of machinery (Claessens & Feijen, 2007). Therefore, the reason why financial development matters to the link between a cleaner CO_2 environment and development is that the financial sector has the ability to render superior financial services to eco-friendly programs that would reduce CO_2 emissions in developing countries (Tamazian, Piñeiro & Vadlamannati, 2009; Onanuga, 2017).

2.2.7 Financial Development and Carbon Financing

Sub-Saharan Africa (SSA) faces the pressing challenge of advancing economic development while simultaneously addressing environmental degradation. The region's vulnerability to climate change, despite its relatively low carbon emissions, has intensified interest in how financial development and carbon financing can mitigate these effects. Financial development—broadly encompassing improved access to credit, financial liquidity, and robust capital markets—plays a significant role in allocating resources efficiently and supporting green investment. Meanwhile, carbon financing, which includes mechanisms such as carbon credits, certified emission reductions (CERs), and climate investment funds (CIF), introduces economic incentives to reduce greenhouse gas emissions and transition toward cleaner energy alternatives (Gillenwater & Seres, 2011; UNFCCC, 2021c).

Financial development impacts the environment in both beneficial and adverse ways. A well-developed financial system can promote investment in clean technologies, green infrastructure, and low-emission industries. Studies such as those by Onanuga (2017) and Tamazian, Piñeiro, and Vadlamannati (2009) argue that financial deepening—especially when aligned with environmental priorities—reduces carbon emissions by channeling capital into sustainable projects. However, other studies caution that in the absence of environmental safeguards, financial development may actually increase emissions by expanding high-carbon sectors. Shen et al. (2021) and Rahman and Alam (2022) find that financial systems often inadvertently facilitate the growth of carbon-intensive industries due to the lack of targeted regulations or incentives for green investments.

In SSA, the role of financial development is particularly nuanced. (Mensah et al. 2023) demonstrate that financial liquidity is a critical enabler for green investments, especially in economies constrained by limited fiscal space. Liquidity enhances the capacity of firms and financial institutions to invest in renewable energy and energy-efficient technologies. However, (Abudu et al. 2022) caution that where credit is heavily skewed toward fossil fuel-reliant sectors, financial development may exacerbate carbon emissions. Similarly, stock market activities measured through indicators such as stock turnover and value traded has dual effects. While active trading in green sectors can drive capital toward sustainable ventures, markets dominated by extractive and high-emission industries can perpetuate environmental degradation (Tang et al., 2022; Rahman & Alam, 2022).

Carbon financing mechanisms have become increasingly important in mobilizing funds for climate-friendly initiatives. Clean Development Mechanisms (CDMs) and Certified Emission Reduction (CER) units, as promoted under the Kyoto Protocol and administered through the UNFCCC, are examples of how developing regions can benefit from global carbon markets. However, participation from SSA remains limited. According to the UNFCCC (2021c), as of 2021, only 2.867% of CDM projects globally were hosted in Africa. The low uptake has been attributed to weak institutional frameworks, inadequate project verification capacity, and limited access to global carbon markets. This underrepresentation has significant implications, as SSA countries many of which are highly susceptible to climate change could greatly benefit from these financial instruments.

The Climate Investment Funds (CIF), established in 2008, offer another avenue for carbon finance. Designed to assist countries in transitioning to low-carbon economies, CIFs support investments in clean technologies and climate adaptation projects. In SSA, however, the disbursement and utilization of these funds have been uneven. While countries like South Africa and Kenya have attracted significant CIF support, others such as Uganda and Chad remain marginalized (Climate Investment Funds, 2023; African Development Bank, 2023). This discrepancy has been linked to structural barriers including policy misalignment, poor financial infrastructure, and limited technical capacity to develop bankable climate projects.

Empirical evidence on the impact of financial development and carbon financing in SSA is mixed. Studies like those of Tsaurai (2019) and Scholtens and Veldhuisa (2015) report a positive relationship between financial development and carbon emissions, suggesting that financial deepening may stimulate environmentally harmful activities. Conversely, findings from Tamazian and Rao (2010), Ntarmah, Kong, and Manu (2021), and Xuezhou, Manu, and Akowuah (2022) highlight that a strong financial system can facilitate reductions in emissions by incentivizing green innovation and supporting low-carbon investments. These conflicting results point to the need for context-specific investigations, particularly in SSA where economic structures, policy frameworks, and environmental risks vary significantly across countries.

Recent research has expanded our understanding of these dynamics. Zhao, Cheng, and Liu (2022) show that financial instruments like green bonds and ESG-linked investment products are beginning to redirect capital flows in emerging economies. Meanwhile, Guo et al. (2022) stress that environmental shocks—such as floods and wildfires—can lead to financial instability by reducing liquidity and disrupting credit markets. Su et al. (2022) add that environmental disasters could trigger liquidity crises in the banking sector, particularly in economies where climate-related financial risks are poorly integrated into macroprudential policies.

Theoretical frameworks such as the Carbon Dioxide Theory and Cobb-Douglas Production Function provide additional insights. The former underscores the greenhouse effect of increased CO_2 concentrations, while the latter illustrates how financial inputs (e.g., capital from banks or markets) interact with production and emissions. As Khudari, Darweesh, and Othman (2024) argue, financial systems can either mitigate or worsen emissions depending on the nature and direction of investments. Thus, aligning financial development with sustainability goals is critical.

From a policy perspective, these findings highlight the need to reform credit allocation frameworks, deepen financial inclusion in green sectors, and integrate climate risk into financial regulation. Financial systems in SSA must be recalibrated to disincentivize carbon-intensive investments while promoting cleaner technologies and sustainable infrastructure. Equally important is the scaling-up of carbon financing mechanisms such as CERs and CIFs, which remain underutilized despite their potential to drive low-carbon development in the region.

In conclusion, the literature indicates that both financial development and carbon financing can significantly influence carbon emissions in Sub-Saharan Africa. Their effects, however, are contingent on the institutional context, policy frameworks, and the direction of financial flows. A proactive alignment of financial systems with climate goals—supported by robust regulation and international cooperation—offers a viable pathway for SSA countries to balance economic growth with environmental sustainability.

2.2.8 Financial Liquidity and Carbon Emissions

Financial liquidity refers to the ease with which assets or securities can be quickly converted into cash without significant loss of value. In the context of carbon emissions, higher liquidity in the financial sector may enhance the ability of firms to invest in cleaner technologies and support projects aimed at reducing emissions, thereby potentially reducing overall greenhouse gas output. However, it can also enable quick capital access for high-emission industries, potentially exacerbating environmental degradation (Shen et al., 2021). According to Mensah et al. (2023), financial liquidity is vital in sustaining green investments in Sub-Saharan Africa, especially in economies where environmental concerns must balance with financial constraints.

The issue of climate change often results in various financial risks, as well as mounting pressure on banks' liquidity. It is even more pronounced in emerging stock markets which face financial frictions. Thus, thorough evaluation of the current liquidity position of banks becomes crucial for understanding the detrimental effect of climate risk on optimal financial strategies for achieving low-carbon emissions. The Paris agreement of 2015 and those of Conference of Parties (COP26), and the recent ones such as COP27 (held in Sharm El-Sheikh in Egypt on November 27, 2022) and COP28 (held from 30 November to 13 December at Expo City, Dubai, United Arab Emirates) are among the major initiatives established to reduce greenhouse emissions, financing low-carbon emissions, and regulating carbon markets. The essence was to provide a workable and efficient financing model for achieving sustained reduced carbon emissions across the globe (Guo et al., 2022; Liang et al., 2020). According to Su et al. (2022), one of the main reasons for COP26 initiative was predicated on the need to consistently assist frontier markets (SSA countries inclusive) in the area of effective and efficient carbon emissions management. The stock markets as well as the banking sector do play significant role in channeling funds between deficit and surplus units. The studies of Umar et al. (2021) and Rizvi et al. (2021) have demonstrated the relevance of stakeholders engaging in green financial practices, and this in turn provides motivation to financial intermediaries. On the other hand, few studies have recognized the detrimental effect of carbon emissions on companies' financial liquidity profile. For example, a situation where issues like bush burning resulting to wild fire, flooding and other natural disasters, among others occur, it will indirectly lead to a situation where customers speedily rush to banks to withdraw their savings spontaneously. If the situation is not properly managed, it can lead to liquidity crises in the banking sector, and when this happens it can also result in confidence evaporation (loss of confidence) in the banking system due to inability to meet up with the daily withdrawal obligations of customers. Thus, Su et al. (2022, p.7) corroborating the above views added that, "the inadvertent reduction in assets can result in a decrease in the bank's liquidity, making it more difficult for the bank to meet its short-term obligations; coupled with the fact that climate change issue is non-linear, and sudden degradation may exert more regulatory pressures resulting in a hard landing for the banking sector".

2.2.9 Value of Stock Traded and Carbon Emissions

Trading of carbon emission in stock market provides an effective medium of internalizing the cost of reducing companies' carbon emissions by transmitting it to the stock market, which in turn affects the overall market value of firms (Tang, Cheng, Guo, Ma & Hu, 2022). According to Veith, Werner and Zimmermann (2009), Fabra and Reguant (2014), appropriate policy on carbon emission trading (CET) may reduce a company's market value because, the company's production costs will increase leading to crowding out of investment expenses. When this information is made available to the capital market through corporate financial reports, the resultant effect is a fall in the market value of the firm. This view was also corroborated by Liu et al. (2021) where they demonstrated that carbon emission trading reduces the overall market value of firms in the stock market. However, other studies such as Bui, Moses and Houqe (2020); Oestreich and Tsiakas (2015) found that carbon emissions enhance the value of the firm when properly traded at the stock market. According to them, giving free permit to carbon emissions trading will allow sales to be accounted for and thereby leading to higher cash flows, and this in turn will spur up the overall value of the firms. With this development, other firms will be attracted to adopt the new policy of green innovation and conform to environmental legitimacy to improve sustainable development ability and by so doing their market value would be enhanced. Hence, Tang, et al. (2022, p. 2) further summed it all that "firms with better carbon emission abatement performance and comparative advantages in terms of abatement cost will provide detailed information disclosures to attract the attention of investors, thereby exerting a positive impact on the firm's market value".

Furthermore, carbon emission trading checkmate companies' aggregate emissions and also raises the costs of emission reduction, compliance, and current technology, thereby reducing the company's market value (Chen, Zhang & Chen, 2021). Also, higher productive firms can effectively engage in ideal activities that meet the government's emission reduction standards, promote competitiveness and profits, and these will help to facilitate the overall market value of firms, thereby increasing the company's market value (Tang, Li, Hu, Wu & Zhang, 2021)

2.2.10 Stock Market Turnover and Carbon Emissions

In the context of the stock market, 'turnover' is also known as 'trading volume' or 'share turnover', which refers to the total value of shares traded during a specific period. Onoh, et.al. (2017). Stock market turnover is the aggregate number of equities traded in a given market over a given period of time and it is measured as total number of shares traded over a given period divided by the average number of shares outstanding for the period. It is one of the parameters for judging the depth, level of liquidity and development of a stock market, Sadorsky, (2011). According to Miao & Li (2023, p. 795-796), increases in the general level of stock market activities indirectly result in increase in energy consumption level. This effect occurs in two dimensions first, when the volume of trade increases (development), it provides fresh avenues of funds for financing firms' growth (equity financing). Thus, it is also regarded as a veritable tool for fast tracking growth and development of a country by facilitating long term funds for firms for productive activities. Secondly, growth is highly linked to energy consumption; as firms continue to expand their productive capacities; more energy is consumed thereby increasing the total level of carbon emissions (Sadorsky, 2011). Therefore, with a developed stock market, quoted firms and investors are able to ease liquidity constraints thereby enabling them to increase total output, aggregate consumption level as well as carbon emissions (Miao & Li, 2023). Abbasi and Riaz (2015) find that volume of traded stock enhances stock market development and in turn increases carbon emissions level; while Chia-Lin, Jukka, Hannu and Michael (2020) submitted otherwise that an increase in stock market volume (development) bring about a drastic reduction in CO_2 emissions. Still, Ralph and Alexander (2019) observed that increases in the volume of traded stock enhance market size and in turn, inversely related to carbon emissions.

2.2.11 Certified Emission Reduction Units (CER) and Carbon Emissions

Certified emission reduction units (CER) are a type of emissions units, carbon credits, issued by the clean development mechanism executive board for emission reductions achieved by CDM projects and verified by a designated operation entity under the rules of the Kyoto Protocol (Certified Emission Reduction Units, 2020). A CER is a 'financial product' such that people who provide financial services in relation to CERs and related financial products and services a certified license which allows them to provide those services (Australian National Registry of Emissions Units Act, 2011). Under the Kyoto rules, a CER is a tradable unit representing one tonne of carbon dioxide-equivalent (tCO_2-e) of emissions abatement or sequestration. They are often traded for registered under the Clean Development Mechanism (CDM), which operates in countries that are non-Annex I Parties to the United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol (developing country Parties). Annex I Parties to the UNFCCC and the Kyoto Protocol (developed country Parties) can use CERs to meet their emissions reduction or limitation commitments (Certified emission reduction units, 2020). CERs are only valid for the commitment period for which they are issued, unless they are 'carried-over' by a Party in accordance with Kyoto rules. Each CER has a serial number made up of a number of different elements which, when combined, create a unique identifier for the CER. The serial number identifies the fact that the unit is a CER, the Kyoto Party that issued the CER, the Kyoto commitment period for which the CER was issued and the CDM project number of the CER. The Climate Convention requires carbon offsets based on certified emission reductions (CERs) to be clearly additional. This criterion demands that selected projects have a credible, quantifiable and verifiable baseline of emissions, from which reductions can be measured and verified. The baseline represents the emissions from electricity generation that would occur in the absence of the certified project activity. The goal is to get a high quality carbon offsets (CERs) such that this quality project depends on the credibility of the project's extra quality. Thus, "the baseline describes the greenhouse gas emissions associated with a counterfactual scenario that would prevail without the JI or CDM intervention and with which actual emissions can be compared" (World Bank, 1999a). The credibility of the baseline is crucial, as this is the key to the acceptance of the project's CERs.

2.2.12 Climate Investment Funds (CIF) and Carbon Emissions

Climate Investment Funds (CIF) is innovative financing mechanism designed to provide resources to developing countries to help them address the challenges of climate change. It was established in 2008 as a collaborative initiative between the multilateral development banks (MDBs) and developed country governments (Climate Investment Funds, 2010). Its creation was driven by the need for an effective and coordinated approach to carbon finance that could deliver substantial and tangible results. The main purpose of the funds is to assist low-carbon and climate-resilient development by investing in clean technology, sustainable forestry, and climate adaptation projects (Stein, 2023).

The funds have been very critical to enhancing the level of carbon finance since its inception in 2008 and, being an $11 billion multilateral lender, the funds is one of the biggest multilateral climate funds across the globe till date. Several governments, the private sector and multilateral development banks are actively involved in the facilitation of these funding to assist countries in the world that are highly vulnerable to climate change (Climate Investment Funds, 2023). For instance, the United Kingdom has over the years consistently supported this pool of funds to the tune of £2.7 billion since its inception in 2008. It even intended building on this funding by the launch of the Climate Investment Funds (CIF) Capital Market Mechanism in 2024. Also, with the launch of Climate Investment Funds (CIF) Capital Market Mechanism in 2024, bonds will be able to generate approximately $750 million yearly with respect to the new climate financing strategy; and about $7.5 billion over the next decade, and this will definitely attract over $50 billion in co-financing for climate projects in emerging and developing economies of which the Sub-Sahara African Countries is a part (Climate Investment Funds, 2020; 2023).

Currently, CIFs comprises of two main funds such as Clean Technology Funds (CTFs) and the Strategic Climate Fund (SCFs). Pledges to these funds from various stakeholders are currently about $4.5 billion and $1.9 billion, respectively (The World Bank, 2020). As at June 8th 2024, climate investment funds is one of the largest active carbon finance mechanisms in the world, with about $12.1 billion pleaded (The World Bank, 2024. Specifically, the Clean Technology Fund (CTF) is expected to provide assistance of about 15 to 20 countries or regional investment plans to meet the criteria of significant greenhouse gas emissions savings and demonstrable potential for scale, fast-track implementation and development impact. Those of Strategic Climate Fund (SCF) focuses on strategic approaches directed at new areas of development centered on low-income country programmes by channeling additional financing for climate change; provides incentives for scaled-up and transformational mitigation and adaptation actions in the context of poverty reduction; extends incentives to maintain, restore or enhance carbon-rich natural ecosystems; and maximize the co-benefits of sustainable development (Climate Investment Funds, 2023).

2.2.13 Bank Credit to Gross Domestic Product and Carbon Emissions

Bank Credit to GDP indicates the level of financial resources provided to the private sector by banks as a percentage of GDP. Bank credit plays a crucial role in funding development, and when directed towards environmentally conscious sectors, it can reduce emissions. For example, Abudu *et al.* (2022) highlight that access to credit can incentivize green practices among firms and support investments in renewable energy. However, when credit heavily supports industries dependent on fossil fuels, it can increase emissions, posing challenges for sustainable financial systems in Sub-Saharan Africa (Heubaum & Volz, 2022). Understanding how bank credit affects environmental outcomes is essential for policymakers in designing credit allocation frameworks that reduce carbon footprints.

Bank's credit is the aggregate sum extended by financial institutions (Bank and Non- Bank Financial Institution) to individuals, businesses and the government, which serves as the lifeblood of economic activities. The effective and efficient disbursement of bank's credit to the public is not merely a financial transaction, but rather a catalyst for private investment. Bank credit also serves as an engine that facilities economic growth of a nation (Luca & Spatafore, 2012; Onwioduokit & O'Neil, 2024). The more enterprises emit carbon into the environment, the less banks grants new loans. Corporate credit rating plays a significant role in moderating the relationship between carbon emission and new bank loans. Carbon emission leads to the improvement of an earnings management of an enterprise, and the significant decline in conservatism and comparability of accounting information. The carbon emission of enterprises will significantly reduce the loan term structure. (Ding, Ren, Tan, & Wu, 2023).

The monetary authorities wield credit policies as potent tools in steering macro – economic growth; through strategic deployment. Credit policies can channel investment into productive and value added ventures, propelling real growth within the economy (Gosh, 2010). The relationship between bank's credit and economic growth serves as a pivotal axis in understanding the trajectory of emerging economies. Schumpeter (1973) emphasizes the role of bank's credit in financing innovation which is a crucial driver of economic growth.

2.3 Theoretical Review

This section comprises a review of different theories related to carbon emissions and financial development. These theories include; Carbon dioxide theory, Cobb-Douglas production function theory, Financial Development theory, Interest group theory of financial development and green models.

2.3.1 Carbon Dioxide Theory

The concentration of carbon dioxide in the atmosphere is about 0.03 per cent by volume, it is fairly uniformly mixed as high as accurate measurements have been made. Water vapor and ozone also exist in very small concentrations in the atmosphere, but the exact amount that is present varies with time and place. The carbon dioxide theory was first proposed by Tyndall (1861). The theory states that, as the amount of carbon dioxide increases, the atmosphere becomes opaque over a larger frequency interval; the outgoing radiation is trapped more effectively near the Earth's surface and the temperature rises. The latest calculations show that if the carbon dioxide content of the atmosphere should double, the surface temperature would rise by 3.6 degrees Celsius and if the amount should be cut in half, the surface temperature would fall to 3.8 degrees (Tyndall, 1861).

The first extensive calculations were necessarily done by very approximate methods. There are thousands of spectral lines due to carbon dioxide which are responsible for the absorption and each of these lines occurs in a complicated pattern with variations in intensity and the width of the spectral lines ((Fleming, 1998). Further the pattern is not even the same at all heights in the atmosphere, since the width and intensity of the spectral lines varies with the temperature and pressure. Only recently was a reasonably accurate solution to the problem of the influence of carbon dioxide on surface temperature made possible with the accurate infrared measurements, theoretical developments, and the availability of a high-speed electronic computer (Tyndall, 1861; Plass, 1956).

However, with respect to water vapor absorption issue, carbon dioxide remains the basis for the frequent opposition to carbon dioxide theory. The reason is that, the water vapor absorption is so large that there would be virtually no change in the outgoing radiation if the carbon dioxide concentration should change. This submission was nevertheless predicated on approximate treatments of the very complex problem of the calculation of the infrared flux in the atmosphere (Tyndall, 1861; Fleming, 1998). But with the recent detailed structure estimation of the spectra of these two gases, evidences abound that they are relatively independent of one another in their influence on the infrared absorption. The reasons for this hinged on two fundamental reasons such as (i) the absence of correlation between frequencies of the spectral lines for carbon dioxide and water vapor and so the lines do not often overlap because of nearly coincident positions for the spectral lines. (ii) The fractional concentration of water vapor falls off very rapidly with height whereas carbon dioxide is nearly uniformly distributed (Tyndall, 1861; Fleming, 1998).

Thus, “the link between the theory of carbon dioxide and financial development (FD), financial development (FD) has the potential to contribute to the mitigation of carbon emissions through funding for initiatives such as renewable energy projects, energy-efficient buildings, and green infrastructure “(Khudari, Darweesh & Othman, 2024, p.3). On the other hand, “it is possible to additionally facilitate an increase in carbon emissions by providing financial support to projects that heavily rely on fossil fuels, such as coal-fired power plants, or by extending loans to enterprises with a substantial carbon footprint: hence, achieving a harmonious equilibrium between advancing the financial sector and mitigating carbon emissions is of utmost importance (Khudari, Darweesh & Othman, 2024, p.3)”.

2.3.2 Cobb-Douglas Production Function Theory

The Cobb-Douglas production function was originally developed by Douglas and Cobb (1920) which seeks to explain the relationship that exist between a given amount of output and two factors of production like capital and labor:

$$Q = AK^{\alpha} L^{\beta} \quad \text{……} \quad 2.1$$

Where: $\alpha + \beta = 1$

The capital K, is the monetary value of physical assets required for production, such as buildings, machinery, and equipment. The labor, L, is the productive effort of the workforce, measured in person-hours. The exponent is a value between 0 and 1 that measures the responsiveness or elasticity of output with respect to capital. For example, an elasticity of $\alpha = 0.5$, or 50%, means that every amount of money (capital) investment translates to an increase in production valued at $0.50. The other exponent, β, is the elasticity of output with respect to labor. The two elasticities are complementary percentages which add up to 100%, reflecting the proportional contributions of each factor to any increase in output (Douglas & Cobb, 1920)

A is a constant known as the total-factor productivity (TFP). The value of A is a ratio of output to total input, and reflects the overall quality or efficiency of the production process. As technology improves, and the skill and education of the workforce increase, enterprises will convert labor and capital to output products more efficiently, meaning the total-factor productivity should rise over time. In this context, it is also pertinent to assume that total factor production (TFP) is not usually constant (Solow, 1957) as a result of advancement in the area of technological innovation, which also effectively links openness, globalization, international competitiveness, and convergences among the countries in the world.

Thus, in this study, the Cobb-Douglas production function theory is effective in explaining carbon emissions and consumption, especially when close economy is assumed with good number of identical households with fixed amount of capital (K) and available labour (L) such that consumption of X, in addition to other direct consumptions such as household electricity E_H, fossil fuels F_H, and leisure or home production L_H. Therefore, consumers maximize that utility subject to their budget, and their welfare also negatively depends on total emissions of carbon dioxide (CO_2) from the use of fossil fuels.

2.3.3 Green Models

Green model is the general equilibrium environment model that was first developed by the Organization for Economic cooperation and development (OECD) secretariat in 1991 as a multi-region and multi-sector applied general equilibrium model for quantification of economic costs of policies targeted at the reduction of carbon emission in the atmosphere. Burniaux et al. (1992) later developed the green model into a dynamic applied general equilibrium model and further expanded to have a global coverage and extended time- horizon, while focusing majorly on the energy sector. The various sectors are assumed to share a common production structure and operate under constant returns-to-scale while quantities of production inputs are chosen in order to cause production costs minimization. The additional income that is needed to acquire post-policy utility levels at the pre-policy prices is given as: $EV = E(PC^n, V^n) - E(PC^b, V^b)$ Burniaux et al. (1992). The green model was also developed in order to ascertain the economic impact of abating carbon dioxide emission (CO_2), using several economic instruments.

2.3.4 Financial Development Theory

Financial development models was developed and advocated by McKinnon and Shaw (1973). According to the theory, “developing economy is financially repressed leading to indiscriminate 'distortions of financial prices including interest rates and foreign exchange rates' reduces the real rate of growth and the real size of the financial system relative to non-financial magnitudes (McKinnon-Shaw, 1973.p 67,73). The central elements and focus of this model is the ‘inside money model’; where money created as loans to the private sector is termed inside money because it is backed by the internal debt of the private sector. Hence, financial institutions intermediate between savers and investors such that savings (Sg_0) at economic growth rate (g_0) is a positive function of the real rate of interest r, measured as the nominal interest rate (ninr) minus the expected inflation rate (ifr) all expressed as continuously compounded proportional rates of change (McKinnon-Shaw, 1973.p 67,73, 77). In this context, household savings are distributed between two assets, tangible assets used as hedges against inflation and deposits earning a nominal interest rate i. where FR represents financial repression consisting of administratively fixed nominal interest rate) that holds the real rate r below its equilibrium level. Thus, actual investment is limited to /0, the amount of expected saving at the real interest rate r0. If the ceiling applied only to savers' interest rates (only to the deposit rate d but not to the loan rate /), the investor/borrower would face an interest rate (inr) the rate that clears the market with the constrained supply of saving. The spread r3-r0 would be spent by a regulated but competitive banking system on non-price competition (advertising and opening new bank branches). These non-price services, however, may not be valued at par with interest payments. Certainly, real money demand invariably declines with a decrease in the explicit real deposit rate of interest. In fact, there are loan rate ceilings as well as deposit rate ceilings in most financially repressed economies where there exist a very few competitive banking systems.

The McKinnon-Shaw model further argued that in the case of financial repression when the rate of interest is low, it discourages deposits that would have been employed to prosecute productive investment. The implication of this is that, repressive policies of the state with respect to ceiling of interest rate level have the tendency of slowing down financial development. But with deregulation of the financial system, there will be competition among banks thereby raising the level of deposit interest rate and in turn promote overall saving culture (Abdulraheem, Ogbeide, Adeboje & Musa, 2019). Therefore, "a rise in interest rate spread the difference between lending rate and deposit rate will cause a fall in savings and a decline in financial development." Some earlier empirical studies such as Guiso, Sapienza and Zingales (2006), Tressel and Detragiache (2008) have demonstrated how banking sector reform/financial liberalization and economic growth can influence financial development. The model of financial development also demonstrated a dual relationship with economic growth such that while the development of domestic financial markets promotes efficiency of capital accumulation, financial intermediation enhances overall savings rate and by extension the level of investment. This position was first stressed by Goldsmith (1969) that, "positive link do exist between financial development and per capita GNP level, due to the observed positive effect financial development on efficient utilization of capital stock."

2.3.5 Interest Group Theory of Financial Development

The interest group theory of financial development was propounded by Rajan and Zingales (2003) which stresses the role of trade and financial openness in reducing the influence of interest groups that oppose financial development. In a closed economy, incumbents benefit from financial repression and the resulting low financial development because it denies potential competitors the financial resources to enter the market. Increasing both trade and capital account openness undermines this status quo. Foreign entry in the domestic goods markets reduces rents and creates more investment needs for incumbents to counter competition and take advantage of new opportunities. At the same time, opening up capital flows renders financial repression increasingly impossible to implement. This theory relied on de facto measures of openness or financial development like trade/GDP or credit/GDP. However, lack of a consistent dataset of regulations across sectors has prevented the possibly most compelling test. However, de facto openness may rise without any trade liberalization or reduction in rents: for example, higher commodity prices would tend to increase de facto openness in both importing and exporting countries with no change in trade policies and, possibly, even with an increase of rents in commodity exporting countries. Similarly, higher de facto financial depth indicators may not be an indication of domestic financial reform or of a smaller role of incumbents in domestic credit markets (Henry, 2007).

Conversely, the interest group theory have also be extended beyond trade and financial openness to include the effect of carbon emissions on financial development as propounded by the earlier works of Lanoie, Laplante and Roy (1998) and Dasgupta, Laplante, Wang and Wheeler (2002). According to them, financial development related factors are very crucial to attaining environmental quality; and that in an egalitarian society where there exists an active financial system, it will be able to provide sufficient motivation for firms to reduce CO_2 emissions. This development can provide appropriate financial motivation like enhanced company's market capitalization. However, detrimental new from the environment like in the form of court actions on violations of environmental regulations would bring about inverse attitude on the capital markets and communities (Onanuga, 2017).

The interest group theory of financial development anchors on the role of trade and financial openness with respect to reducing the influence of interest groups that oppose financial development. In a closed economy, incumbents benefit from financial repression and the resulting effects of low financial development may deny potential competitors the financial resources to enter the market. Increasing both trade and capital account openness, undermines this status quo. Foreign entry in the domestic goods markets reduce rents and creates more investment needs for incumbents to counter competition and take advantage of new opportunities (Cagatay et al., 2012, p. 1). It is important to note that, the tests of interest group theory depend so much on de facto measures of openness or financial development, for example trade/GDP or credit/GDP (Cagatay et al., 2012, p. 1); and Rajan & Ramcharan, 2008).

Having considered the theories related, this study is hinged on the Cobb-Douglas Production Function Theory. The reason was because the theory provides a clear understanding of how production inputs such as capital (financial investments) and labor contribute to economic output while considering environmental constraints like carbon emissions. The theory's focus on the elasticity of output concerning capital and labor aligns with the study's objectives, particularly in examining how financial mechanisms, such as banks' credits to GDP, value and volume of stock traded, and climate investment funds, impact carbon emissions.

By incorporating the effects of financial investments on production processes, the theory supports the analysis of how financial development influences greenhouse gas emissions through the funding of energy-intensive or green projects. Furthermore, its relevance to resource allocation and efficiency provides a framework for assessing the trade-offs between economic growth and environmental sustainability, which is at the heart of the study's objectives. Thus, the

Cobb-Douglas Production Function Theory effectively ties financial development, carbon financing, and emissions reduction in Sub-Saharan Africa.

2.4 Empirical Literature

Several authors carried out empirical studies that are related to the study. They are discussed under following subheadings:

2.4.1 Financial Development and Carbon Financing

Rahman and Alam (2022) conducted a panel data study across 17 Asia–Pacific countries for the period 1960 to 2020. The study examined the effect of financial development alongside energy consumption, economic growth, and international trade on carbon emissions. The results indicated that financial development significantly increased CO_2 emissions, confirming a direct environmental impact of increased financial activities. Interestingly, the square of economic growth was found to reduce emissions, supporting the Environmental Kuznets Curve (EKC) hypothesis.

Emenekwe, Onyeneke, and Nwajiuba (2022) investigated the effect of financial development and economic growth on carbon emissions in 37 SSA countries over the period 2000 to 2016. Using a dynamic GMM approach, the study established that financial development reduces carbon emissions in the region and provides evidence in support of the EKC hypothesis. This suggests that as SSA countries mature economically and financially, they begin to implement cleaner technologies and emission-reducing mechanisms.

In another study focusing on SSA, Xuezhou, Manu, and Akowuah (2022) examined the relationship between financial development and environmental quality across seven SSA countries from 1980 to 2017. Using a panel vector autoregressive model, they found a negative impact of financial development on CO_2 emissions in four subregions (Western, Southern, Northern, and Central Africa), while in Western Africa, financial development was found to increase emissions. The study also partially confirmed the EKC hypothesis, showing variations in the environmental impact of financial development across regions.

Zhao, Cheng, and Liu (2022) also investigated how financial development affects environmental sustainability using data from emerging economies between 2000 and 2020. Their study revealed that ESG-linked financial development tools, such as green bonds, contribute to reducing emissions. However, the environmental impact varied based on financial system maturity and regulatory strength, indicating that such instruments may have limited effectiveness in countries with weak institutions—a situation typical of many SSA countries.

Yang, Tan, Chu, and Chen (2022) studied 283 Chinese cities from 2006 to 2019 to assess the influence of financial development on CO_2 emissions. Employing panel data analysis, the study found a significant positive effect of financial development on carbon emissions. Additionally, it was observed that industrial upgrading also positively impacted carbon emissions, suggesting that economic expansion through industrialization, even when financially supported, tends to increase emissions.

Guo et al. (2022), focusing on China, employed a spatial Durbin and stepwise regression model to examine the spillover effects of green financing on carbon emission reduction between provinces. Although green finance significantly reduced emissions locally, its spillover effects were found to be weak. This raises important considerations for SSA, where regional integration and coordination are essential for scaling green finance impacts.

On the subject of carbon financing, the same study by Nwabueze et al. (2023) evaluated the roles of Certified Emission Reduction (CER) units and Climate Investment Funds (CIF). While CER mechanisms were found to be ineffective in reducing emissions due to institutional weaknesses and low market participation in SSA, CIFs were reported to significantly reduce carbon emissions. This aligns with the findings of Zhout et al. (2023) and Mamun et al. (2023), which confirmed that direct financing through CIFs results in long-term emissions mitigation through infrastructure development and energy investments.

Finally, Rehmam et al. (2023) showed that in the U.S. context, financial constraints actually increase firm-level carbon emissions. While this study focused on a developed country, the implication for SSA is notable: financial constraints common in African capital markets could hinder green investment and force firms to stick with cheaper, dirtier technologies.

2.4.2 Financial Development and Carbon Emissions

Tamazian, Pinẽiro and Vadlamannati (2009) examined the effect of economic development, financial development on CO_2 emissions for the BRIC countries (Brazil, Russia, India and China) for the period 1992 to 2004. The panel data technique was employed in the analysis of data and the findings showed that significant positive effect of economic development and financial development on CO_2 emissions.

Tamazian and Rao (2010) examined the effect of financial development on carbon emissions for 24 transition economies such as former Soviet Union (FSU) and Central and Eastern Europe (CEE) for a period of 1993 to 2004. The Generalized Least Squares (GLS) and Generalized Method of Moments (GMM) estimation was employed in this regard and the outcome of the analysis of data revealed that, while their result confirmed the EKC hypothesis, financial development was found to have detrimental effect on carbon emissions.

Asghari (2013) examined the effect of economic growth and financial development on CO_2 emissions in four euro-Mediterranean countries for the period 1980 to 2011 using the simultaneous equations technique for the analysis of data. The outcome of the findings showed that financial development and GDP per capita squared significantly impact environmental quality on one hand, while there is an existence of the EKC and financial development plays a determinant role in CO_2 emissions reductions.

Al-Mulali, Chong, Low and Mohammed (2015) investigate the effect of financial development and trade openness on carbon emissions in 93 countries for the period 1980 to 2008. Using the panel data technique, it was found that urbanization and trade openness increase ecological footprint while financial development reduces the ecological footprint of Low or Middle Income

Countries (LMIC), Upper Middle Income Countries (UMIC) and High Income Countries (HIC). Meanwhile, they found that urbanization, trade openness and financial development have no significant effect on the ecological footprint of Low Income Countries (LIC) because these variables compared with other income groups are low in LIC.

Salahuddin, Gow and Ozturk (2015) examine the effects of economic growth, electricity consumption and financial development on CO_2 emissions for the Gulf Cooperation Council (GCC) countries for the period 1980 to 2012. The Dynamic Ordinary Least Squares (DOLS), Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Fixed Effect Model (DFE) were employed for the analysis of data. The outcome of the finding indicates that electricity consumption and economic growth have a positive relationship with CO_2 emissions while a negative relationship was found between CO_2 emissions and financial development.

Kim and Park (2015) examine how financial development affects carbon emissions in 30 selected countries from America, Asia and Oceania and Europe for the period 2000 to 2013. Using the panel data analysis, they found that financial development has a positive and significant impact on carbon emissions, while countries with well-developed financial systems experienced a disproportionate growth in carbon emissions as compared to poorer countries.

Al-Mulali, Tang and Ozturk (2015) examined the effect of financial development on CO_2 emission in 129 countries for the period 1980 to 2011. Employing the dynamic OLS and the Granger causality test results also show that financial development can improve environmental quality in the short run and long run due to its negative effect on carbon emissions.

Scholtens and Veldhuisa (2015) analyzed the impact of financial development on carbon emissions of 198 countries over the period 1980 to 2008. They utilized the panel data analysis and the GMM econometric techniques, and the outcome of the analysis revealed that financial development as measured by the size of the commercial banking sector, commercial bank credit to the private sector and the size of the financial industry has a positive impact of carbon emissions.

Alom et al. (2017) investigate the impact of urbanization, financial development and energy consumption on carbon emissions in Bangladesh over the period 1985 to 2015. They employed the vector error correction model (VECM) and the finding revealed that financial development had a significant positive impact on carbon emissions.

Kong and Wei (2017) studied the relationship between financial development and carbon emissions in 30 China provinces for the period 1997 to 2013. They employed the panel data analysis and the findings showed that low financial development reduced carbon emissions whereas higher levels of financial development increase the level of carbon emissions.

Nasreen et al. (2017) investigate the relationship between financial stability, economic growth, energy consumption and carbon emissions (CO_2) emissions in South Asian countries over the period 1980 to 2012. The study employed a multivariate framework and the findings indicate that financial stability improves environmental quality; while financial development reduces carbon emissions.

Ojewumi and Akinlo (2017) examined the impact of foreign direct investment and economic growth on environmental quality in Sub-Saharan Africa (SSA) for the period 1981 to 2015. They used panel vector error correction (PVEC) and panel vector autoregressive (PVAR) methods in analysis of data, and the result revealed among others that economic growth and foreign direct investment significant and positively impact carbon emissions level in the SSA region.

Onanuga (2017) examine the impact of economic and financial development on CO_2 emissions in 45 Sub-Saharan Africa (SSA) countries under the framework of EKC and STIRPA for the period 1989 to 2012. Using the unbalanced panel data technique, the findings showed significant positive relationship between financial development, economic growth and carbon emissions, which also varied across the sampled 24 low (LIC), 13 lower-middle (LMIC), six upper-middle (UMIC) and two high-income countries (HIC) respectively.

Bekhet, Matar and Yasmin (2017) examined the causal relationships among, financial development, economic growth, energy use, and carbon emissions in Gulf Cooperation nations for the period 1980 to 2011. They employed the ARDL technique for the analysis of data and the results indicate that a long-run and causal relationship exist among the hypothesized variables for all the countries.

Koçak and Şarkgüneşi (2018) employed the structural break cointegration test, bootstrap test OLS techniques to analyze the effect of foreign direct investment on carbon emissions in Turkey for the period 1974 to 2013. The outcome of the analysis of data showed that an existence of long run link among FDI, GDP, energy use, and carbon emissions. The study also revealed that FDI has a potential impact on carbon emissions as well as a bidirectional link with carbon emissions.

Iskandar (2019) empirical investigation of EKC hypothesis with respect to CO_2 emission and EG in Indonesia for the period 1981 to 2016 used the ARDL analysis and found that the EKC hypothesis does not hold in the country.

Balcilar, Ozdemir, Tuncsiper and Shahbaz (2019) study on the nexus between CO_2 emissions, Embodied Carbon and EG in G-7 countries, used the historical decomposition technique and observed a trade off on Embodied Carbon in order to minimize CO_2 emissions in US, Canada and Italy; while the EKC does not hold in the case of UK and Germany, Embodied Carbon has a positive effect on environmental quality.

Ssali, Du, Mensah and Hongo (2019) investigate the link among environmental contamination, economic growth, energy use, and foreign direct investment in 6 selected Sub-Saharan African nations for a period of 34 years (1980 to 2014). They employed the auto-regressive distributed lag technique, it was found that a significant relationship exist among the hypothesized variables. It was also found that a bidirectional causality exist between energy use and CO_2 in the short-run and one-way causality running from energy use to CO_2 in the long run. There is additionally a significant positive outcome and unidirectional causality from CO_2 to foreign direct investment in the long run yet no causal relationship in the short run.

Sarkodie and Strezov (2019) analyzed the effect of foreign direct investment (FDI) inflows, economic growth, and energy use on carbon emissions in China, India, Iran, Indonesia, and South Africa for the period 1982 to 2016. These countries were considered as the leading carbon emitters in the emerging economies. Using the panel data analysis, it was observed while that energy consumption has significant positive effect on carbon emissions; FDI inflows significantly impact eco-technological transfer, strengthened labor and eco-friendly management in emerging economies.

Tsaurai (2019) investigate the impact of financial development on carbon emissions in West African countries for the period 2003 to 2014. They employed the pooled ordinary least squares (OLS) and found that domestic credit (one of the measures of financial sector development) significantly impact carbon emissions in Western African countries.

Bayar, Maxim and Maxim (2020) examined the effect of financial development, primary energy consumption and economic growth on carbon emissions in 11 post-transition European economies for the period 1995 to 2017. They employed the panel co-integration and causality analyses and the results showed a weak relationship between financial sector development and carbon emissions in the short run; an while in the long run, there was a significant positive effect of financial sector development and primary energy consumption on carbon emissions. A bi-directional causality was found between primary energy consumption and economic growth on one hand, and carbon emissions on the other.

Bui (2020) investigated the direct and indirect effects of financial development on carbon emissions in a global sample of 100 countries for the period 1995 to 2018. Using the 2SLS and 3SLS techniques, it was found that financial development has significant positive impact on environmental degradation. Development of the financial system also gives rise to more energy demand and consequently leads to more pollutant emissions.

Aluko and Obalade (2020) examined the effect of financial development on environmental quality of 35 SSA countries for the period 1985 to 2014. Coupled with the direction of causality between financial development and environmental quality. Employing the panel data analysis, augmented mean group estimator and granger causality test techniques, it was observed that financial development has significant negative effect on carbon emissions; and a bidirectional causal relationship between financial development and CO_2 emissions.

In an attempt to minimize the impact of carbon footprints on Diponegoro University environment, Syafrudin et al. (2020) employed the panel method to analyze carbon footprint under three stages such as the Greenhouse Gas Protocol, electricity usage activities and transportation, wastewater, and solid waste treatment activities. The results showed that the largest contributor to carbon footprints came from the electricity and transportation activities in the 1st and 2nd stage.

Khan, Khan and Rehan (2020) investigated the impact of CO_2 emissions, energy consumption on economic growth in Pakistan for the period 1965 to 2015. Using the ARDL econometric technique, EC and Growth significantly impact CO_2 emissions both in the short run and in the long run.

Kılavuz and Doğan (2021) examined EKC preposition in Turkey for the period 1961 to 2018. Using the ARDL, the finding confirmed its existence, with CO_2 playing dominant role, while trade openness has no significant impact.

Ntarmah, Kong and Manu (2021) examined the link between credit supply, economic growth, and the environment using four sub-regional economies (Central, East, Southern, and West African regions) in the SSA for the period 1990 to 2018. In addition, the study tested Environmental Kuznets Curve hypothesis across sub-regions. Using the panel vector autoregressive (panel VAR) model in a generalized method of moment framework, the findings indicate that economic growth negatively influence carbon emissions in Central African countries but not in the East, Southern and West African sub-regions; credit supply had significant positive impact on carbon emissions and economic growth of Central and East African sub-regions but negative influence on carbon emissions and economic growth West African sub-regions in SSA; carbon emissions had significant negative impact on credit supply of East and West African sub-regions.

Chireshe (2021) examined the relationship between financial development and renewable energy development of 17 selected Sub-Saharan African Countries for the period 2000 to 2016.

Employing the system generalized methods of moments (GMM) estimation; it was found that financial development has significant positive relationship with renewable energy production in the sub-region.

Rahman and Alam (2022) investigated the impacts of energy consumption, economic growth, financial development, and international trade on the CO_2 emissions of 17 Asia–Pacific countries. The employed the panel data analysis for the 1960 to 2020 and the findings indicate that energy consumption, financial development, economic growth, and international trade have adverse effects on the environment of the panel countries by increasing the CO_2 emissions, whereas the square of economic growth reduces it. Also, unidirectional causal link from CO_2 emissions to energy consumption and economic growth was also confirmed.

Yang, Tan, Chu and Chen (2022) examined the effect of financial development on CO_2 emissions on a panel study of 283 Chinese cities for the 2006 to 2019. Using the panel data analysis technique, the outcome of the analysis revealed that financial development significantly and positively impact carbon emissions. It was also observed that upgrading of industrial structures has significant positive impact on carbon emissions.

Xuezhou,Manu and Akowuah(2022) examined the effect of financial development (FD) and economic growth on environmental quality in SSA countries for the period 1980 to 2017. The Sub-Saharan African region is considered to be the most susceptible to the effects of climate change. The region's climate is influenced by several factors, the most notable of which is increased variation in development. The conglomerate between the financial sector and environmental quality (EQ) has been a priority for policymakers and analysts. The study also tested the EKC hypothesis and utilized the panel vector autoregressive (PVAR) model in a generalized method of moment for the analysis of data. The outcome of the finding showed that while financial development had a negative impact on CO_2 in four geographical regions (Western, Southern, Northern, and Central); it had a positive impact on carbon emissions in Western Africa. The EKC hypothesis was confirmed in Western African sub-region but was rejected in Central and Eastern.

Emenekwe, Onyeneke and Nwajiuba (2022) examined the relationship between financial development, economic growth and carbon emissions for 37 Sub-Saharan African (SSA) countries for the period 2000 to 2016. The dynamic generalized method of moment estimator was used to provide robustness checks. The findings indicate that overall FD reduces CO_2 emissions in the region and supports the environmental Kuznets curve (EKC) hypothesis.

Nwabueze, Abner, Victor, Nwude, Samuel and Udo (2023) examine the impact of foreign direct investment and financial development carbon emissions in 17 Sub-Saharan African countries for the period 1999 to 2022. Employing the pooled mean group and Dumitrescu and Hurlin panel causality tests for analysis of data, it was found that financial development positively and significantly impact green energy consumption in Sub-Saharan Africa and in various income-level countries. However, in the lower-middle-income countries in the SSA, carbon emissions and financial development had a negative and significant link.

2.4.3 Carbon Financing and Carbon Emissions

In another related study by Yan et al. (2016) on the carbon credit-FDI and carbon emissions nexus, and in relation to the EKC "U" shaped relationship with carbon dioxide intensity in China for the period 2005 to 2014. The outcome of the findings using the regression analysis showed that scale of financing, financial industry competition, and credit fund allocation have a significant inhibitory effect on carbon emission intensity.

Lin, Chen and Qiu (2018) try to ascertain whether green financing significantly affect carbon emissions, environmental protection companies and related companies over the period 2008 to 2016. Employing the regression analysis, they found that green finance significantly impacts flow of credit funds to the environmental protection industry and environmentally friendly industries and thus, directly influenced carbon dioxide emissions.

Wu (2018) examined the effect of carbon credits/financing on carbon emissions in China over the period 2010 to 2016. Employing the multiple regression, it was found that bank credit has an effect on the scale and technological aspect of carbon emissions.

Chen (2019) investigate the effect of green financial policies on carbon emissions in China for the period 2011 to 2017; employed the double-difference model analysis technique and found that green financial policies has detrimental effect on investment and financing of high-polluting enterprises, especially in the area of financing punishment and investment inhibition. Xie and Liu (2019) on the effect of carbon credits on carbon emission over the period 2008 to 2017 used the panel data econometric technique on analysis of data. It was found that green credit promotes green growth mainly by improving technological progress. De-Haas and Popov (2019) examined the effect of structure of carbon financial systems on carbon emissions for several European countries for the period 1990 to 2013. Using the panel data analysis technique, it was found that for equity-funded industries, CO_2 emissions per capita are lower compare to others. Also, stock markets invested more funds to less polluting industries, and also push carbon-intensive sectors to develop and implement greener technologies.

Li, Liu, Hou, Xu and Chao (2019) examine the effect of carbon financing on carbon emission in the Beijing-Tianjin-Hebei region for the period 2010 to 2016. Employing the logarithmic mean divisia index model, the empirical analysis showed that green credit can reduce carbon emissions, carbon trading increases carbon emissions. Therefore, the gradual expansion of carbon finance trading and market mechanism of carbon finance to solve the problem of carbon emission can improve the efficiency of carbon emission reduction.

Ding (2019) examined the impact of green credit financing on environmental degradation and emissions for the period 2007 to 2017. The regression analysis was used for the analysis of data, and the finding indicate that when heavily polluting enterprises face the constraints of green credit financing, it reduces their overall capital allocation, which became insufficient and thereby causes decline in aggregate factor productivity.

Niu, Zhang and Zhang (2020) examined the relationship between green financial policies and green enterprise in China over the period 2010 to 2018. The multiple regression analysis was employed and the findings indicate that, while green financial policies positively impact green enterprise, those of green credit policy on financing cost and emissions were insignificant.

Jiang, Wang, Wang and Wu (2020) investigate the impact of green credit on carbon emission reduction in China for the period 2010 to 2018. Using the panel data analysis method, the findings revealed that green credit is significantly and negatively related to carbon emission.

Guo, Wang, Cao and Hou (2022) in their study on carbon emission reduction through the use of carbon financing processes in Yangtze River Economic Belt in China for the period 2006 to 2019. Employing the spatial Durbin and stepwise regression model (SDM) on analysis of data, it was observed that while green financing has significant positive role in carbon emission reduction, its spillover effect on neighboring provinces are generally weak and insignificant.

Rehman, Shahzad, Hanif, Arshad and Sergi (2023) examined the effect of financial constraints on firm carbon emissions of 1,536 US firm for the period 2008 to 2019. The pooled ordinary least square, as well as two-step generalized method of moment–based dynamic panel data analysis was also used. The outcome revealed that financial constraints enhance the carbon emissions of the firms.

Zhou, Zhou, Zhang and Chang (2023) investigated the relationship between green financing and industrial carbon emissions in China for the period 2005 to 2020. Employing the panel data analysis technique, the findings indicate that green financing has significant negative impact on industrial carbon emissions in China.

Mamun et al. (2023) examined the impact of green financing on carbon emissions of 46 OECD countries for the period 2005 to 2020. Using the co-integration technique, it was found that green financing has significant inverse effect on carbon emissions.

From the existing literature on carbon footprint nexus, we observed a lot of studies have been investigated on the effect of carbon emissions on economic growth (Bimanatya & Widodo, 2018; Sabbaghi & Sabbaghi, 2018; Li, Liu, hou, Xu & Chao, 2019; Amuakwa-Mensah & Adom, 2017; Aye & Edoja, 2017; Olubuoye & Dasuki, 2018, 2020; Khan, Khan & Rehan, 2020); impact of financial development and carbon emissions on economic growth (Tamazian, Pinẽiro & Vadlamannati, 2009; Ojewumi & Akinlo, 2017; Onanuga, 2017; Ssali, Du, Mensah & Hongo, 2019; Chireshe, 2021); and the effect of carbon emissions on financial development (Shen et al., 2021; Wang et al., 2020; Rahman & Alam, 2022), among others. To the best of the researcher's knowledge, no prior studies have been carried out in the sampled SSA countries on the combined effect of financial development and carbon financing on carbon emissions. Most of the studies found are in China, Europe and the US. Thus, in order to effectively close this gap in the empirical literature, calls for this current study.

2.5 Summary Table of Reviewed Empirical Literature

Table 2.1: Summarized Table of Empirical Literature

S/N	Author(s)/year	Country	Period of Study	Methodology	Findings
1	Tamazian, et al. (2009)	BRIC Countries	1992 to 2004	Panel Data Analysis	Significant positive effect of economic development and financial development on CO_2 emissions
2	Tamazian and Rao (2010)	Central and Eastern Europe	1993 to 2004	GLS and GMM	Financial development was found to have detrimental effect on carbon emissions
3	Asghari (2013)	Four Euro-Mediterranean Countries	1980 to 2011	Simultaneous equations	Financial development and GDP per capita squared significantly impact environmental quality
4	Al-Mulali, et al. (2015)	Ninety- three Countries across the Globe	1980 to 2008	Panel Data Technique	Urbanisation and trade openness increase ecological footprint while financial development reduces the ecological footprint of LMIC, UMIC and HIC; trade openness and financial development have no significant effect on the ecological footprint of LIC because these variables compared with other income groups are low in LIC
5	Kim and Park (2015)	America, Asia and Oceania and Europe	2000 to 2013	Panel data analysis	Financial development has a positive and significant impact on carbon emissions, while countries with well-developed financial systems experienced a disproportionate growth in carbon emissions as compared to poorer

					countries
6	Al-Mulali, et al. (2015)	One hundred and twenty-nine countries across the Globe	1980 to 2011	Dynamic OLS and the Granger causality	Financial development can improve environmental quality in the short run and long run due to its negative effect on carbon emissions
7	Scholtens and Veldhuisa (2015)	One hundred and ninety-eight countries across the Globe	1980 to 2008	GMM	Financial development as measured by the size of the commercial banking sector, commercial bank credit to the private sector and the size of the financial industry has a positive impact of carbon emissions
8	Salahuddin, et al. (2015)	Gulf Countries	1980 to 2012	FMOLS and DFE	Electricity consumption and economic growth have a positive relationship with CO_2 emissions while a negative relationship was found between CO_2 emissions and financial development
9	Yan et al. (2016)	China	2005 to 2014	Regression analysis	Scale of financing, financial industry competition, and credit fund allocation have a significant inhibitory effect on carbon emission intensity
10	Alom et al. (2017)	Bangladesh	1985 to 2015	VECM	Financial development had a significant positive impact on carbon emissions
11	Kong and Wei (2017)	China	1997 to 2013	Panel data analysis	Low financial development reduced carbon emissions whereas higher levels of financial development increases the level of carbon

					emissions
12	Nasreen et al. (2017)	South Asian Countries	1980 to 2012	Multivariate framework	Financial stability improves environmental quality; while financial development reduces carbon emissions
13	Ojewumi and Akinlo (2017)	Fifteen SSA Countries	1981 to 2015	Panel vector error correction and panel vector Autoregressive	Economic growth and foreign direct investment significant and positively impact carbon emissions level in the SSA region
14	Onanuga (2017)	Forty-five SSA Countries	1989 to 2012		Significant positive relationship between financial development, economic growth and carbon emissions, which also varied across the sampled 24 low (LIC), 13 lower-middle (LMIC), six upper-middle (UMIC) and two high-income countries (HIC) respectively
15	Bekhet, et al. (2017)	Gulf Countries	1980 to 2011	ARDL	A long-run and causal relationships exist among the hypothesized variables for all the countries
16	Alom et al. (2017)	Bangladesh	1985 to 2015	VECM	Financial development had a significant positive impact on carbon emissions
17	Koçak and Şarkgüneşi (2018)	Turkey	1974 to 2013	Bootstrap test OLS	An existence of long run link among FDI, GDP, energy use, and carbon emissions

18	Lin, et al. (2018)	China	2008 to 2016	Regression analysis	Green finance significantly impact flow of credit funds to the environmental protection industry and environmentally friendly industries and thus, directly influenced carbon dioxide emissions
19	Wu (2018)	China	2010 to 2016	Multiple regression	Bank credit has an effect on the scale and technological aspect of carbon emissions
20	Iskandar (2019)	Indonesia	1981 to 2016	ARDL	CO_2 emission affect EG
21	Balcilar, et al. (2019)	G-7 countries	1980 to 2017	Panel data analysis	A trade off on EC in order to minimize CO_2 emissions; EC has a positive effect on environmental quality
22	Ssali, et al. (2019)	Six SSA Countries	1980 to 2014	ARDL	A significant relationship exist among the hypothesized variables
23	Sarkodie and Strezov (2019)	China, India, Iran, Indonesia, and South Africa	1982 to 2016	Panel data analysis	Energy consumption has significant positive effect on carbon emissions, FDI inflows significantly impact eco-technological transfer, strengthened labor and eco-friendly management in emerging economies
24	Tsaurai (2019)	West African Countries	2003 to 2014	Pooled ordinary least squares (OLS)	Domestic credit (one of the measures of financial sector development) significantly impact carbon emissions in Western African countries

25	Chen (2019)	China	2011 to 2017	Double-difference model	Green financial policies has detrimental effect on investment and financing of high-polluting enterprises, especially in the area of financing punishment and investment inhibition
26	De-Haas and Popov (2019)	European Countries	1990 to 2013	Panel data analysis	For equity-funded industries, CO2 emissions per capita are lower compare to others; also, stock markets invested more funds to less polluting industries, and also push carbon-intensive sectors to develop and implement greener technologies
27	Xie and Liu (2019)	China	2008 to 2017	Panel data analysis	Green credit promotes green growth mainly by improving technological progress
28	Iskandar (2019)	Indonesia	1981 to 2016	ARDL	CO_2 emission affect EG
29	Li, et al. (2019)	China	2010 to 2016	logarithmic mean divisia index model	Green credit can reduce carbon emissions, carbon trading increases carbon emissions
30	Ding (2019)	Europe	2007 to 2017	Regression analysis	When heavily polluting enterprises face the constraints of green credit financing, it reduces their overall capital allocation, which became insufficient and thereby causes decline in aggregate factor productivity
31	Bayar, et al. (2020)	Eleven European	1995 to 2017	Panel cointegration and causality	A weak relationship between financial sector development and carbon emissions in the short run;

		Countries		analyses	an while in the long run, there was a significant positive effect of financial sector development and primary energy consumption on carbon emissions
32	Bui (2020)	One hundred Countries across the Globe	1995 to 2018	2SLS and 3SLS	Financial development has significant positive impact on environmental degradation
33	Aluko and Obalade (2020)	Thirty-five SSA Countries	1985 to 2014	Panel data analysis, augmented mean group	Financial development has significant negative effect on carbon emissions; and a bidirectional causal relationship between financial development and CO_2 emissions
34	Syafrudin et.al (2020)	Pakistan	1982 to 2018	Panel data analysis	Largest contributor to carbon footprints came from the electricity and transportation activities in the 1st and 2nd stage
35	Khan, et al. (2020)	Pakistan	1965 to 2015	ARDL	EC and Growth significantly impact CO_2 emissions both in the short run and in the long run
36	Niu, et al. (2020)	China	2010 to 2018	Multiple regression analysis	While green financial policies positively impact green enterprise, those of green credit policy on financing cost and emissions were insignificant
37	Jiang, et al. (2020)	China	2010 to 2018	Panel data analysis	Green credit is significantly and negatively related to carbon emission

38	Bui (2020)	One hundred Countries across the Globe	1995 to 2018	2SLS and 3SLS	Financial development has significant positive impact on environmental degradation
39	Kılavuz and Doğan (2021)	Turkey	1961 to 2018	ARDL	Confirmed its existence, with CO_2 playing dominant role, while trade openness has no significant impact
40	Ntarmah, et al. (2021)	Ten SSA Countries	1990 to 2018	Panel VAR	Economic growth negatively influence carbon emissions in Central African countries but not in the East, Southern and West African sub-regions; credit supply had significant positive impact on carbon emissions and economic growth of Central and East African sub-regions but negative influence on carbon emissions and economic growth West African sub-regions in SSA; carbon emissions had significant negative impact on credit supply of East and West African sub-regions
41	Chireshe (2021)	Seventeen SSA Countries	2000 to 2016	GMM	Financial development has significant positive relationship with renewable energy production in the sub-region
42	Rahman and Alam (2022)	Seventeen Asia–Pacific Countries	1960 to 2020	Panel data analysis	Energy consumption, financial development, economic growth, and international trade have adverse effects on the environment
43	Yang, et al.	China	2006 to	Panel data	Financial development significantly

	(2022)		2019	analysis	and positively impact carbon emissions; also upgrading of industrial structures has significant positive impact on carbon emissions
44	Xuezhou, et al. (2022)	Seven SSA Countries	1980 to 2017	Panel vector autoregressive	While financial development had a negative impact on CO_2 in four geographical regions (Western, Southern, Northern, and Central); it had a positive impact on carbon emissions in Western Africa
45	Emenekwe, et al. (2022)	Thirty-seven SSA Countries	2000 to 2016.	The dynamic generalized method of moment	Overall FD reduces CO_2 emissions in the region and supports the environmental Kuznets curve (EKC) hypothesis
46	Guo, et al. (2022)	China	2006 to 2019	Spatial Durbin and stepwise regression model	While green financing has significant positive role in carbon emission reduction, its spillover effect on neighboring provinces are generally weak and insignificant
47	Nwabueze, et al. (2023)	Seventeen SSA Countries	1999 to 2022	Pooled mean group and Dumitrescu and Hurlin panel causality tests	Financial development positively and significantly impact green energy consumption in Sub-Saharan Africa and in various income-level countries; However, in the lower-middle-income countries in the SSA, carbon emissions and financial development had a negative and significant link
48	Rehmam et al. (2023)	US	2008 to 2019	Pooled ordinary least square	Financial constraints enhance the carbon emissions of the firms
49	Zhout et al.	China	2005 to	Panel data	Green financing has significant negative impact on industrial

	(2023)		2020	analysis	carbon emissions in China
50	Mamun et al. (2023)	OECD Countries	2005 to 2020	Cointegration techniques	Green financing has significant inverse effect on carbon emission

Source: Author's Compilations 2024

Table 2.1 is a summary of fifty reviewed empirical literature on the dependent and independent variables employed in the study. They showed different relationships and effects between and among the variables.

2.6 Gaps in the Empirical Literature

From the reviewed empirical literature and Table 2.1, we observed conflicting findings with regard to how financial development and carbon financing affect carbon emissions. For instance, the findings of Tamazian, Pinẽiro and Vadlamannati (2009); Scholtens and Veldhuisa (2015); Onanuga (2017); and Tsaurai (2019) indicated significant positive relationship between financial development and carbon emissions: but those of Tamazian and Rao (2010); Al-Mulali, Tang and Ozturk (2015); Ntarmah, Kong and Manu (2021); Rahman and Alam (2022); Xuezhou, Manu and Akowuah (2022); Nwabueze, Abner, Victor, Nwude, Samuel and Udo (2023) concluded a significant negative relationship between financial development, carbon financing and carbon emissions in their respective studies. Now, given this mixed finding, this study is carried out in order to ascertain the extent to which financial development and carbon financing have affected carbon emissions in the Sub-Saharan African countries.

Furthermore, it is clear that the above study lacks adequate empirical work conducted in Sub-Saharan African; the African studies are very few. That is, there is paucity of empirical studies relating financial development, carbon financing to carbon emission in Sub-Saharan African region. The table also showed that, there are contradictory results occurring from the various methodologies adopted in 'financial development, carbon financing and carbon emission'. In this case, not too many studies used 'Autoregressive Distributed Lag' as a technique in Sub-Saharan Africa. The uniqueness of the ARDL lies in its ability to analyze dynamic relationships in time series data, particularly when dealing with variables that are integrated of different orders (1(0) or 1(1)), and its capacity to estimate both short-run and long-run relationship simultaneously.

Finally, In terms of method of data analysis, we observed from the reviewed empirical literature that most studies like Niu, Zhang and Zhang (2020) either used multiple regression; Koçak and Şarkgüneşi (2018) used bootstrap (OLS); Chireshe (2021), Emenekwe, Onyeneke and Nwajiuba (2022), Scholtens and Veldhuisa (2015) employed the GMM method. Alomet et al. (2017) utilized VECM; Tamazian and Rao (2010) used the GLS; Asghari (2013) used the cointegration, panel data analysis, simultaneous equations. To the best of the researcher's knowledge, only few studies like. Bekhet, Matar and Yasmin (2017) employed the ARDL. This study therefore utilized the autoregressive distributed lags (ARDL)-based estimation framework. However, for the panel data, the ARDL framework crystalizes into the Pooled Mean Group (PMG) analysis technique which also generates both short run and long run estimates within a panel data framework. The specific advantage of the ARDL- based estimation model is the ability to analyze both short-run and long-run dynamics, and they can handle variables with different orders of integration. This is an important feature that is unique to ARDL estimation.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter addresses the method and the specific processes involved in the analysis of the data on the relationship between financial development, carbon financing and carbon emission in Sub-Sahara Africa. Thus, the relevant procedures include among others; research design, population of the study, sample size, sources of data, theoretical framework, model specification, method of data analysis and measurement of variables.

3.2 Research Design

The research design adopted for this study is the longitudinal survey (expost facto) research design. This method entails the use of historical data to gain knowledge about some phenomenon over a period of time, as well as quantitative, statistical or regression method in evaluating the research issues or problems. The reason is that, the expost facto research design assumed that the variables have already occurred such that the researchers cannot vary or manipulate the data.

3.3 Population and Sample

The population of the study is the Sub-Sahara African Countries. The UN Development Programme (2023) classified the SSA countries as 49 African countries (See appendix). The stratified sampling techniques will be adopted in this study. With the stratified approach, the SSA countries are divided into sub-groups according to the level of carbon emitters as well as a functioning financial system. From this, the filtering technique will be employed to determine suitable sample countries to be included in the study based on the levels of carbon emitters as well as data availability. This study will therefore draws out a sample of seven (7) SSA countries such as Cote d' Ivoire, Ghana, Kenya, Mauritius, Namibia, Nigeria, and South Africa because they are regarded as the highest emitters of carbon dioxide (CO2) in 2023 in the SSA region (Sasu, 2023). Due to heavy dependence on fossil fuel coupled with the slow pace of adapting and implementing renewable energy and greenhouse gas.

3.4 Sources of Data

The data for this study is an annual times series data covering a period of 24 years (2000 to 2023). In order to obtain accurate and reliable data, data was sourced from the World Bank Development Indicators (WBDI) and the International Monetary Fund (IMF) Financial Structure Database.

3.5 Theoretical Framework

The theoretical framework for this study is anchored on the Cobb–Douglas (1920) production function given as:

$Q = AK^{\alpha} L^{\beta}$ ……………………………………………………………..…………………3.1

Where: $\alpha + \beta = 1$

The capital K, is the monetary value of physical assets required for production, such as buildings, machinery, and equipment. The labour, L, is the productive effort of the workforce, measured in person-hours. The exponents α and β is the elasticity of output Q with respect to capital. The other exponent, β, is the elasticity of output with respect to labor. The two elasticities are complementary, reflecting the proportional contributions of each factor to any increase in output. Therefore, equation 3.1 is slightly modified and linked to the consumption-based CO_2 (GHG) to renewable energy consumption alongside financial development and carbon financing variables. The expanding financial development variables such as financial liquidity (FINL), banks' credits to GDP (BC/GDP), value of stock traded (VAST) and stock market turnover (TURN); as well as carbon financing variables like certified emission reduction unit (CERs) and climate investment funds (CIFs) as a major component of globalization, makes it to account for environmental pollution.

However, in order to gain degrees of freedom by the addition of variability of time-series dimension coupled with intention to control for the unobserved country specific effects, the Cobb–Douglas production function is further transformed into a panel data approach in a panel dataset. The reason is that, a dynamic panel estimator can produce consistent and efficient estimates when the country-specific effects are correlated with the lagged independent variables. Hence, the model takes the following general form:

$Y_{i,t} = \beta_1 Yi_{,t-1} + \beta_2 X_{i,t} + u_{i,t}$……………………………………………………………..3.2

$u_{it} = n_i + \varepsilon_{i,t}$

Extending equation 3.2, we have:

$Y_{i,t} = \beta_1 Y_{i,t-1} + \beta_2 X_{i,t} + n_i + \varepsilon_{i,t}$ ……………………………………………………………3.3

Where: $u_{it} = n_i + \varepsilon_{i,t}$ is the composite error; i,t = countries and time period; n_i and $\varepsilon_{i,t}$ are the idiosyncratic disturbances; $Y_{i,t}$ represents logarithm of GHG; $Y_{i,t-1}$ is the logarithm of GHG at the beginning of the period; $X_{i,t}$ = explanatory variables other than lagged GHG measure; n_i = the unobserved country-specific effect of country i; $\varepsilon_{i,t}$ are the observed-specific error of country i at time period t.

Thus, endogeneity problem arises as a result of the lagged dependent variable as independent variables in equation 3.2 and 3.3 above. This further shows that if OLS method is used it will produced an upward biased coefficient estimates in the presence of individual-specific effects (Hsiao, 1986). To overcome/address this problem, the ARDL estimation is used Bekhet, Matar and Yasmin (2017). The ARDL general estimation principle is that it models the relationship between a dependent variable and its own past values (auto regressive components) and the past values of one or more independent variables (distributed lag component). This can be formalized in general estimation principle in a panel data framework using the general notation;

$$Y_{it} = \beta_0 + \beta_1 Y_{i,t-1} + \beta_2 X_1 i,t + \beta_3 X_{2i,t} + U_{i,t} \ldots\ldots 3.4$$

Where:

Y_{it} = Total greenhouse gas emissions

X_1 i,t = Financial development variables (financial liquidity, banks' credits to GDP, value of stock traded and volume of stock traded) and carbon financing variables (certified emission reduction unit and climate investment funds)

$X_{2i,t}$ = Contemporaneous (and lagged) independent variables

Furthermore, for the purpose of clarity, the extended form of equation 3.4 is restated in its econometric form as follows:

$$GHG_{it} = \beta_0 + \beta_1 GHG_{it-1} + \beta_2 FINL_{it} + \beta_3 BC/GDP_{it} + \beta_4 VAST_{it} + \beta_5 TURN_{it} + \beta_6 CERS_{it} + \beta_7 CIF_{it} + \beta_8 X_{it} + U_{iz} \ldots\ldots (3.5)$$

Where:

GHG = Total Greenhouse gas emissions

FINL = Financial Liquidity

BC/GDP = Banks' Credits to GDP

VAST = Value of Stock Traded

TURN = Stock market turnover rate

CERs = Certified Emission Reduction Unit

CIFs = Climate Investment Funds

X = Vector of control variables including the rate of urbanization (URB) and the level of Manufacturing activities (proxied by manufacturing value added – MVA).

3.6 Model Specification

The focus of this study is to examine the impact of financial development and carbon financing on carbon emission in Sub-Sahara Africa. The model specified for this study follows the background provided by Rose, (2017) and Dimitrios, Helen & Mike, (2016), where the endogeneity between carbon emission and both financial development and carbon financing variables are taken into account. Hence, a dynamic panel data structure was developed for the estimation of the relationship. The fundamental advantage of a panel data set over a cross section is that, it allows the researcher great flexibility in modelling differences in behaviour across individuals. The basic framework for the model is:

$$y_{it} = \lambda y_{it-1} + x'_{it}\beta + \alpha_i + \mu_t + \varepsilon_{it} \quad \text{(3.1)}$$

Where:

y= The dependent variable,

x= A vector of independent variables,

i= The indicator of cross sections,

t= The indicator of period,

α= A cross-sectional fixed effects factor,

μ= The period of fixed effects factor,

ε= The stochastic error term.

This model can also be estimated using the Pooled Mean Group (PMG) procedure. The specified models are therefore in the form indicated in (3.1).

Model 'A' is financial development and carbon emission. This model shows that carbon emission is influenced by financial development indicators. It is specified as:

$GHG = f(FD)$ ……………………………………………………………………….. (3.2)

Where:

GHG= Greenhouse Gases

FD = Financial Development

In this study, financial development was decomposed into the following elements; financial liquidity, banks' credits to GDP, value of stock traded and stock market turnover ratio. The econometric model is thus presented below;

$$GHG_{it}= \partial_0 + \partial_1 FINL_t + \partial_2 BC/GDP_{it} + \partial_3 VAST_{it} + \partial_4 TURN_{it} + \mu_t + \varepsilon_{it} \quad (3.3)$$

Model 'B' Carbon financing and carbon emission. This model reveals that carbon emission is influenced by carbon financing. The general form of the model is specifies as:

$GHG = f(CF)$……………………………………………………………………………(3.4)

Where:

GHG = Greenhouse Gases

CF = Carbon Financing

In this study, CF was decomposed into; certified emission reduction units (CERs), and climate investment funds (CIF).The econometric model is thus presented below;

$$GHG_{it} = \partial_0 + \partial_1 CERs_t + \partial_2 CIFs_{it} + \alpha_i + \mu_t + \varepsilon_{it} \qquad (3.5)$$

Model 'C' is the complete model. This is a combination of all variables in one equation:

GHG = f (FD, CF)

The econometric model is thus presented below;

$$GHG_{it} = \partial_0 + \partial_1 FINL_t + \partial_2 BC/GDP_{it} + \partial_3 VAST_{it} + \partial_4 TURN_{it} + \partial_5 CERs_{it} + \partial_6 CIFs_{it} + \partial_7 URB_{it} + \partial_8 MVA_{it} + \varepsilon_{it} \qquad (3.6)$$

Where:

GHG= Greenhouse gasses

FINL= Financial liquidity

BC/GDP= Banks' credit to GDP

VAST= Value of stock traded

TURN= Market turnover ratio

CERs= Certified emission reduction units

CIF= Climate investment funds

URB = Urban population rate (Control variable)

MVA = Manufacturing value added to capture manufacturing production (Control Variable).

ε= is the error term

i (i = 1, 2, 3, …,7) = Individual country

t (t = 1, 2, 3, …, 24) = time component (years)

The appriori expectations are $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6 < 0$; $\beta_7, \beta_8 > 0$.

Following Pesaran, Shin, and Smith (1999), the PMG (based on the autoregressive distributed lag - ARDL analysis) form of *Eq. (3.8)*is as follows:

$$GHG_{it} = \sum_{j=1}^{\rho} \lambda_{ij}\, FINL_{i,t-j} + \sum_{j=1}^{\rho} \lambda_{ij}\, BC/GFP_{i,t-j} + \sum_{j=1}^{\rho} \lambda_{ij}\, TURN_{i,t-j} + \sum_{j=1}^{\rho} \lambda_{ij}\, VAST_{i,t-j}$$

$$+ \sum_{j=1}^{\rho} \lambda_{ij}\, CER_{i,t-j} + \sum_{j=1}^{\rho} \lambda_{ij}\, CIF_{i,t-j} + \sum_{j=1}^{\rho} \lambda_{ij}\, MVA_{i,t-j} + \sum_{j=1}^{\rho} \lambda_{ij}\, URB_{i,t-j} + \upsilon_{it} \ldots. (3.7)$$

Where $i = 1, 2, \ldots, N$ represents the number of groups (countries), $t = 1, 2, \ldots, T$ indicates the number of periods (years); the coefficient of the lagged dependent variable, λ_{ij}, are scalars; X_{it} is k x 1 vector of the independent variables for the i^{th} group; δ_{ij} represents k x 1 coefficient vectors; and μ_i captures the fixed effect. T is to be sufficiently large in order to independently ensure model fit for each group.

The reparametized *Eq. (3.7)* in the error correction form is as follows:

$$\Delta\, GHG_{it} = \Phi_i\, GHG_{i,t-1} + \beta_i^{'} X_{i,t} + \sum_{j=1}^{\rho-1} \lambda^{\bullet}{}_{ij} \Delta\, GHG_{i,t-1} + \sum_{j=0}^{q-1} \delta^{\bullet'}{}_{ij}\, \Delta X_{i,t-j} + \varepsilon_{it} \ldots (3.8)$$

Where

$$\Phi_i = -\left(1 - \sum_{j=1}^{\rho} \lambda_{ij}\right), \ \beta_i = \sum_{j=0}^{q} \delta_{ij},$$

$$\lambda^{\bullet}{}_{ij} = -\sum_{m=j+1}^{\rho} \lambda_{im}, j = 1,2,\ldots,\rho - 1$$

$$\delta^{\bullet}{}_{ij} = -\sum_{m=j+1}^{q} \delta_{im}, j = 1,2,\ldots,q - 1$$

X = vector of all independent variables.

Given that N and T are large, Pesaran et al. (1999) suggested that the pooled mean group (PMG) estimator is an effective determinant, which depends upon an intermediate approach that strikes a balance between the fixed-effect and mean group approaches. The PMG estimator permits error variances and short run coefficients to oscillate across groups under the assumption that long run coefficients are homogeneous.

3.7 Method of Data Analysis

The theoretical framework for the study has demonstrated that the relationship between the financial development and carbon emission is dynamic (i.e., it changes from positive to negative between the short run and the long run). Thus, an estimation method that takes into account the dynamic relationship of the variables needs to be employed. In this case an autoregressive distributed lags (ARDL)-based estimation framework is adopted in the study. For the panel data, however, the ARDL framework crystalizes into the Pooled Mean Group (PMG) analysis technique which also generates both short run and long run estimates within a panel data framework. However, the PMG model, which combines averaging and pooling, permits the error variances, intercept and short-run coefficients to differ across panel units, while constraining the long-run coefficients to be homogenous or equal across the spatial dimension (Pesaran et al., 1999). It is likely, that this estimation method will depict the true characteristics of the data and generate relatively more consistent and reliable average parameter estimates. The model is also able to provide both long-run and short-run empirical estimates simultaneously.

3.8 Pre-Estimation Procedure

3.8.1 Tests of Time Series Properties of Data

A. Panel Unit Root Tests

Panel data contain both time series and cross-sectional structure. This implies that there is also need to avoid spurious regression when using panel data. Hence, the stationary status of the dataset is tested in this study. In this study, the panel unit root tests proposed by Levin, Lin & Chu [LLC], (2002) and Im, Pearan & Shin [IMP] (2003) were employed. This invariably improves the robustness checks on the analysis. The formulations by Levin et al. [or LLC]have the assumption of a common unit root process so that the coefficient of serial correlation (α_i) is identical across cross-sections. In addition, the null hypothesis the test is that of a unit root. LLC (2000) consider panel versions of the Augmented Dickey–Fuller (ADF) unit root tests. These tests restrict the coefficient of the lagged dependent variable "to be identical across cross-sectional units, but allow the lag order for the first difference terms to vary across cross-sectional units, which in this study are countries" (Adegboye & Arodoye, 2023).

B. Panel Cointergration test

Once the stationarity test is established, we will next test the long run relationships among the variables. There is a number of equations to be estimated in the study, hence the tests were be conducted on a model by model basis. This test was carried out to check for the presence of cointegration which is a check for long run relationship between employment and the structural/demographic factors. The Panel Cointegration tests formulated by Pedroni (1999) and Kao (1999) will be utilised.

3.8.2 Test of Cross-section Dependence Test

Another important data property test that will be conducted in this study is the test for the cross-sectional dependence of the datasets used. This will help to disentangle the crucial features of the relevant variables taking into consideration the issue of cross-sectional dependence in the data. Since the study focuses on the financial sectors of the SSA economies, there is expected to be some form of cross-sectional serial-correlations in their performance among the countries. In this study, the Pesaran (2004) cross-sectional tests will be adopted.

3.9 Measurement of Variables

The variables of interest in this study are measured in this sub-section. The dependent variable is total greenhouse gas emission; the explanatory variables are financial liquidity, banks' credit to GDP, value of stock traded, stock market turnover, certified emission reduction unit and climate investment fund.

Table 3.1: Measurement of Variables

S/N	Variables	Definition	Type of Variable	Measurement	Source	Apriori sign.
1	GHG	Total greenhouse gas emissions	Dependent Variable	Aggregate GHG emissions (inclusive of forest, land use, kilotonne of CO_2equivalent) amongst others.	Hu et al. (2019); World Bank Development Indicators (n.d.); Yang, Tan, Chu and Chen (2022) Obayagbona (2023).	
2	FINL	Financial Liquidity	Independent	The measures the overall level of financial liquidity in the economy. It is captured as the ratio of broad money supply to GDP.	Wang, Vo, Shahbaz and Ak (2020); Yang, Tan, Chu and Chen (2022)	-

3	BC/GDP	Banks' Credits to GDP	Independent	Aggregate credits granted to theprivate sector as a ration of GDP in a given period.	Yang, Tan, Chu and Chen (2022), Yuan, Liao & Wang (2022)	-
4	VAST	Value of Stock Traded	Independent	The value of shares traded is the total number of shares traded, domestic and foreign, multiplied by their respective matching prices	Osho (2014), Obayagbona and Osayande (2020)	-
5	TURN	Stock market turnover	Independent	It is measured as total number of shares traded over a given period divided by the average number of shares outstanding for the period	Osho (2014); Obayagbona and Osayande (2020)	-
6	CERs	Certified Emission Reduction Unit	Independent	Measured as the total number of CERs	Li, Liu, hou, Xu & Chao (2019)	-
7	CIF	Climate Investment Funds	Independent	SREP+CTF+FIP+PPCR funding from CIP programme	AFDB-CIF (2015)	-
8	URB	Urbanization	Control Variable	Urban population as a percentage of total population	World Bank (WDI	±
9	MVA	Manufacturing Value Added	Control Variable	Manufacturing value added as a percentage of GDP	World Bank (WDI)	+

Source: Author's Compilations, 2024

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.1 Introduction

In this chapter, the focus is on the presentation and analysis of the data as well as estimation and interpretation of the models used for the empirical evaluation of the study. The estimation results are presented in line with the working objectives of the study. The analysis involves the use of both statistical and econometric methods in order to provide a rich background for the investigation. The basic characteristics of the dataset are outlined by the descriptive statistics, including charts and correlation analysis. These statistics are used to provide the initial pattern of movements and co-movements of the datasets so as to form the background for the analysis on the basis of inferential statistics. The Econometric analysis is performed based on the models specified in the previous Chapter following the objectives of the study. In particular, a dynamic framework was devised for the empirical analysis and the pooled mean group (PMG) estimation technique is used for the empirical analysis. However, the tests for cross-sectional dependence are conducted and appropriate estimation techniques that account for this dependence are also adopted for robustness check of the empirical estimates.

4.2 Descriptive Statistics

The pattern of data characteristics is initially highlighted by presenting trends in relevant variables and then the related summary statistics. This provides expensive insights into the pattern of movement of the data over time and across the sampled countries. Figure 1 shows the carbon emission per capita for the selected countries in the study. The chart illustrates greenhouse gas (GHG) emissions per capita for seven sub-Saharan Africa (SSA) countries. It is seen that South Africa has the highest per capita emissions throughout the period, significantly outpacing the other countries. The trend for South Africa suggests that the country's energy-intensive industries and heavy coal reliance were at their peak in the mid-2000s. More recently, there appears to be a gentle transition toward cleaner energy. Mauritius and Namibia show moderate emission levels but remain well below South Africa's level while Nigeria, Ghana, Kenya, and Côte d'Ivoire have relatively lower emissions per capita, suggesting minimal per-person carbon footprints.

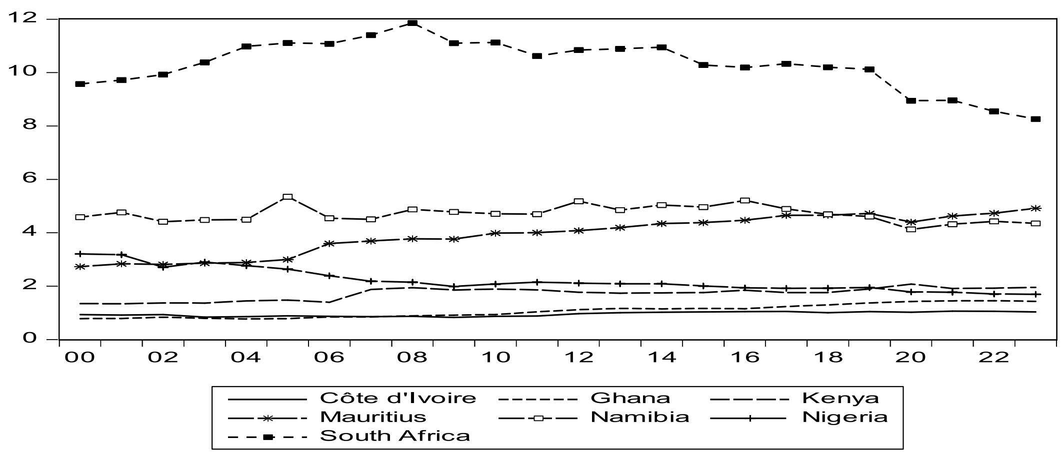

Fig. 4.1: GHG emission per capita

Source: Author's computation (E-View, 14)

Although the overall trend in GHG emission per capita varies among the countries, some of the countries experienced gradual increases while others show stable or declining patterns. Specifically, the figure reveals that Nigeria has one of the lowest per capita emissions among the observed countries. The emissions remain low and stable over time. It appears that the pattern of economic growth in Nigeria has not been driven mainly by highly polluting industries, unlike South Africa.

The trends in credit supply depth (credit-to-GDP ratio) among the countries are shown in Figure 4.2. In the Chart, South Africa has the highest credit-to-GDP ratio throughout the period. This outcome is significantly above all other countries in the sample. Mauritius and Namibia maintain moderate levels that are consistently higher than the other economies except for South Africa. Similarly, Nigeria, Ghana, Kenya, and Côte d'Ivoire exhibit low credit penetration which reflects limited financial sector depth in the countries. The trends show that some countries exhibit stable growth credit penetration while others exhibit fluctuations or declining trends. Once, again, the trend of credit-to-GDP ratio is mostly flat for Nigeria with the implication that credit expansion is essentially still low in the country. This may highlight structural financial challenges in the credit market in the country. For instance, there are issues of high lending rates, weak credit infrastructure, and informality in Nigeria's economy which consistently weaken the credit market in Nigeria.

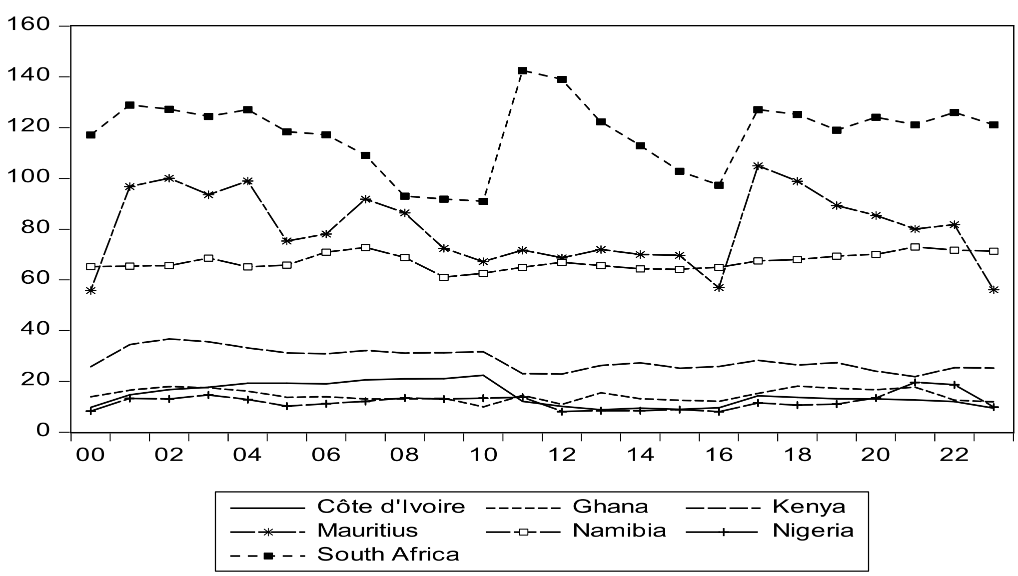

Fig. 4.2: Trends in Credit to GDP ratio

Source: Author's computation (E-View, 14)

The trends in financial liquidity are similar to the credit penetration trend for the countries. South Africa still leads in terms of financial depth among the countries, while Mauritius also has high levels. The West African countries also have low financial depth based on the financial liquidity trends in the Figure3. This shows that South Africa and Mauritius are the top financial development countries in SSA.

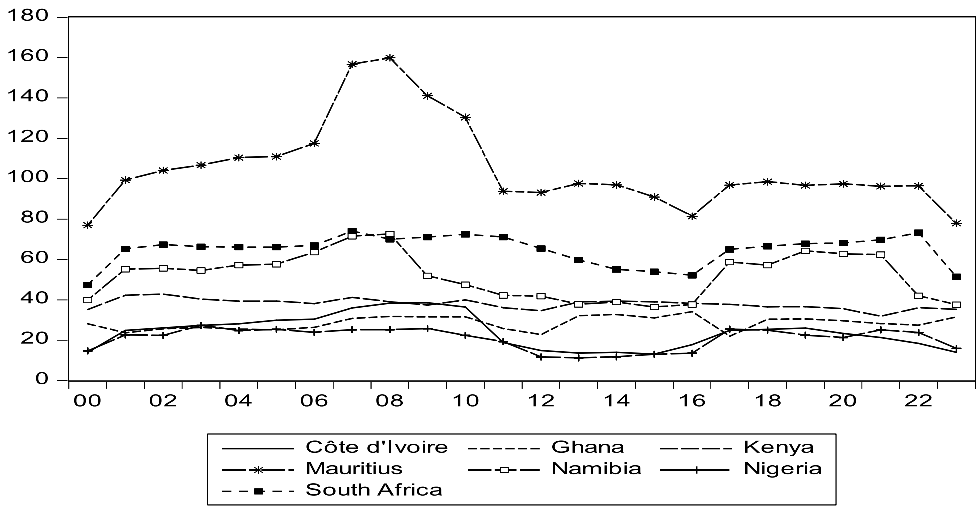

Fig. 4.3: Financial liquidity (Financial depth)

Source: Author's computation (E-View, 14)

Figure 4 presents trends in stock market turnover for the selected SSA countries over the period of the study. Stock market turnover, typically measured as the ratio of total traded value to market capitalization, serves as an indicator of liquidity and efficiency in financial markets. The market turnover rates for most countries exhibit sharp fluctuations over time with rapid variations between periods of high and low market activity. Countries like South Africa and Nigeria exhibit relatively higher turnover rates compared to others like Côte d'Ivoire and Mauritius. This means that the larger economies tend to have stronger investor participation in some markets. For many of the countries, there are significant spikes in the trend around 2008-2010 and 2021. These periods appear to correspond to global or regional economic events impacting market activity.

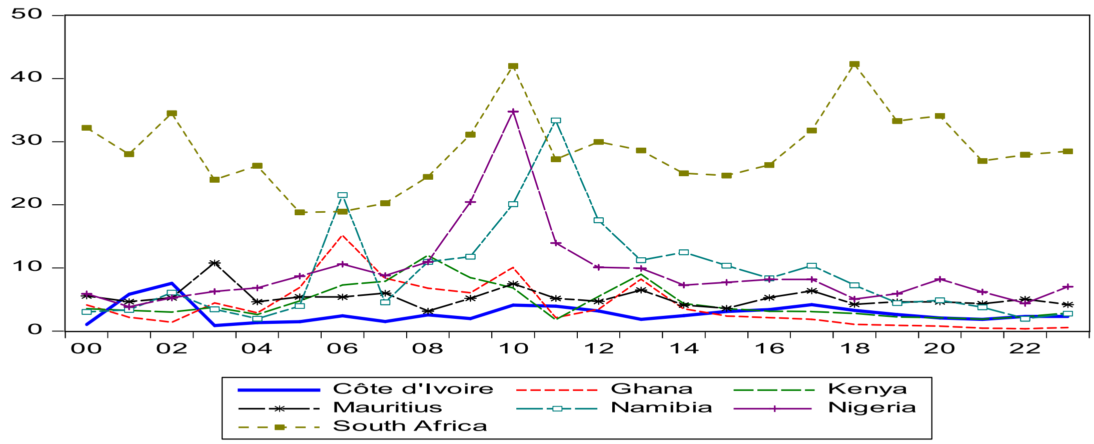

Fig. 4.4: Market turnover trends

Source: Author's computation (E-View, 14)

Trends in market value traded are also reported in Figure 4.5. It is seen that South Africa has a clear lead in terms of value traded in the stock markets. This confirms South Africa's dominance in terms of the stock market performance as well as in relation to overall financial sector development among SSA countries.

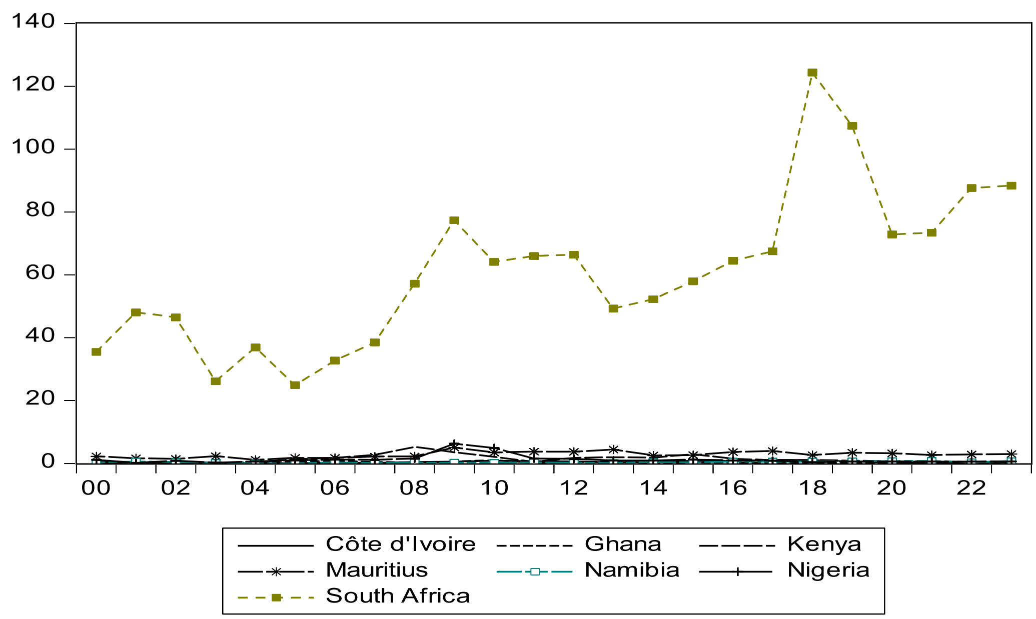

Fig. 4.5: Trends in value traded ratio

Source: Author's computation (E-View, 14)

The chart in Figure 4.6 illustrates the trends in Certified Emission Reduction (CER) units for the selected SSA. Recall that CER units are carbon credits issued under the Clean Development

Mechanism (CDM) of the Kyoto Protocol, which allows developing countries to earn tradable credits by implementing emission-reduction projects. These credits can be sold to industrialized nations to help meet their emission reduction targets. The CER units for most SSA countries have shown a steady increase over time which mean that there are possible gradual adoptions of emission reduction projects. Indeed, many of the countries experienced an acceleration in CER units between 2012 and 2018. This can be related to domestic policy shifts in climate concerns as well as changes in international climate commitments in recent years. There is also significant variability in CER across the countries which reflect differences in climate policies and carbon market participation. For instance, while some countries like South Africa and Nigeria have consistently higher CER levels, others like Côte d'Ivoire have lower levels. Specifically, South Africa has the largest number of CER units, while Côte d'Ivoire and Mauritius have consistently had the smallest number of CERs over the period of the study.

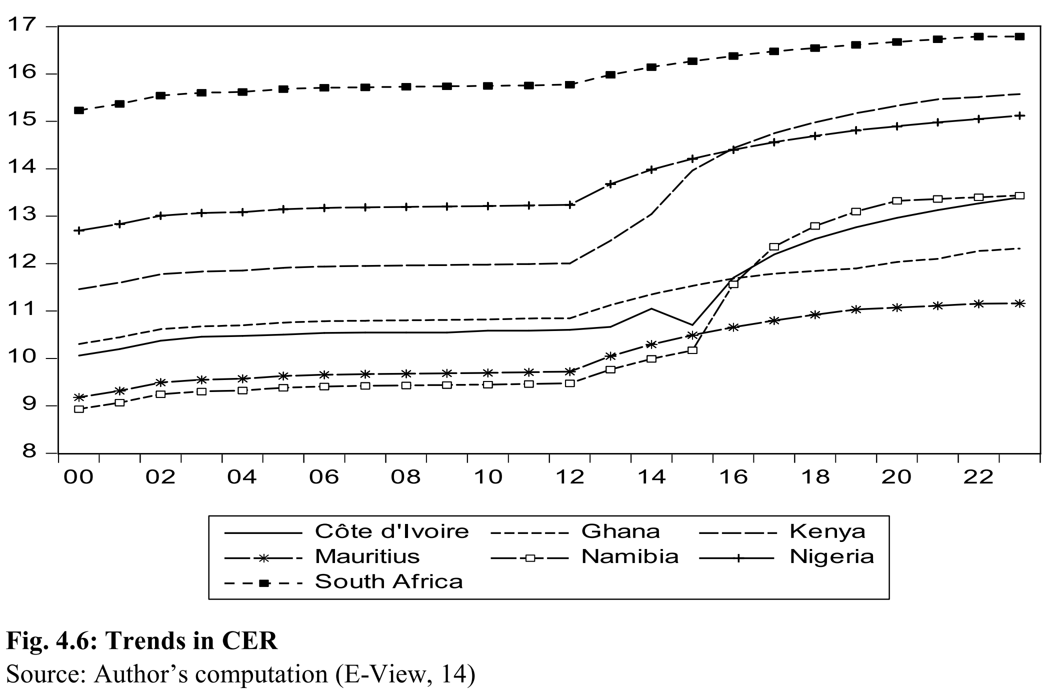

Fig. 4.6: Trends in CER
Source: Author's computation (E-View, 14)

Figure 4.7 shows that trends in Climate Investment Funds (CIFs) which are multilateral funds designed to support developing countries in transitioning toward low-carbon and climate-resilient economies. These funds play a crucial role in financing renewable energy projects, climate adaptation, and sustainable development initiatives. It is seen that CIF allocations have generally increased across all SSA countries over time, indicating greater investment in climate mitigation and adaptation. Also, there is clear acceleration of CIF allocations to SSA countries post-2010. The noticeable increase in CIFs therefore coincides with global carbon finance efforts under the UNFCCC and the Paris Agreement. South Africa, Nigeria, and Kenya lead in terms of CIF allocations, while Côte d'Ivoire and Mauritius have generally lower allocations.

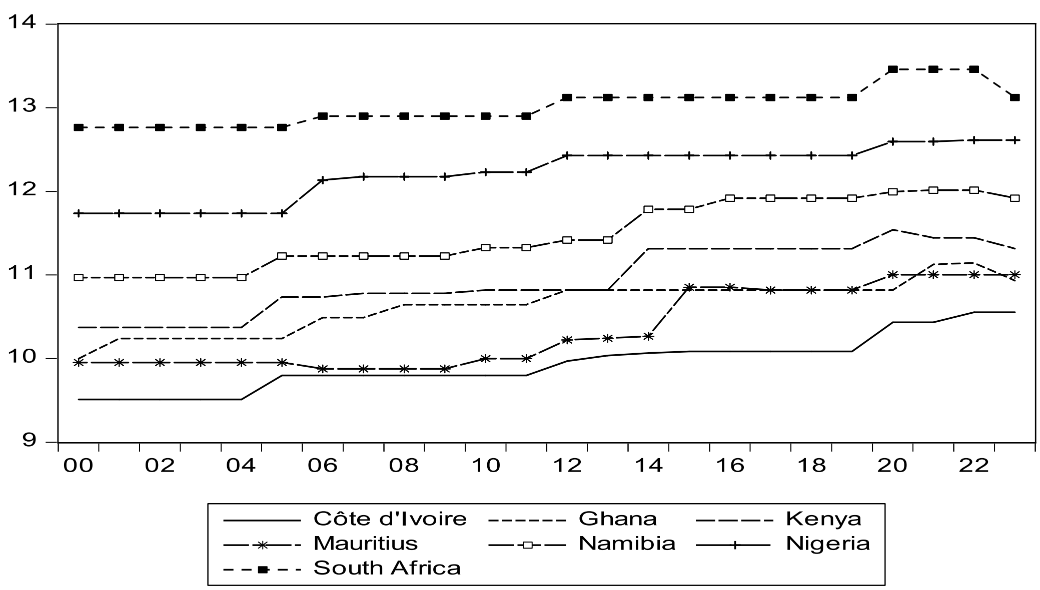

Fig. 4.7: Trends in CIF

Source: Author's computation (E-View, 14)

Deeper evaluation on the initial patterns of the dataset is obtained by presenting the descriptive statistics of the variables. The descriptive statistics are presented in Table 4.1. Average greenhouse gas emissions per capita are 3.56 which is a moderate emissions level per person among SSA countries. This suggests that, on average, an individual in SSA contributes 3.56 metric tons of CO_2-equivalent (CO_2e) emissions per year. This figure reflects a moderate emission level, which is much lower than in industrialized nations such as the U.S. (15 metric tons) or China (8 metric tons). The relatively low emissions indicate that most SSA economies are not highly industrialized. Maximum emission per capita is 11.86 which indicate some that some countries have much higher emissions per capita than the mean score. The distribution for greenhouse gas emissions per capita is right-skewed at 1.37. This means that a few countries have very high per capita emissions, while most countries have relatively low emissions. This is common in regions where industrialized economies (e.g., South Africa) coexist with low-carbon economies.

Average bank credit to GDP ratio (BC_GDP) is 47.77 percent which shows a moderate credit penetration in SSA economies. The maximum ratio of 142.42 is however very large and shows that at least one country in the sample has deep credit markets relative to GDP. Financial intermediation appears to be developing although there is still insufficient penetration compared to advanced economies where bank credit exceeds 100 percent of GDP. Average financial liquidity (broad money to GDP ratio or financial depth) is 47.61 percent which is similar to that of bank credit ratio. Given that financial liquidity measures the availability of liquid financial assets in the economy, the average of 47.61 percent shows that financial liquidity is at a moderate level indicating that money supply is expanding but still not optimal.

Table 4.1: Descriptive Statistics

Variable	**Mean**	**Max.**	**Min.**	**Std. Dev.**	**Skew.**	**Kurt.**	**J-B**	**Pro.**
GHGPC	3.56	11.86	0.77	3.10	1.37	3.76	56.59	0.00
BC_GDP	47.77	142.42	8.08	39.09	0.75	2.24	19.69	0.00
FINL	47.61	159.95	11.30	29.66	1.35	4.75	72.86	0.00
TURN	9.44	80.38	0.35	10.97	2.64	13.13	913.19	0.00
VASTR	9.67	124.37	0.05	22.98	2.75	10.06	561.12	0.00
CERS	1934558.0	19613899.0	7546.5	4038967.0	2.78	10.57	617.56	0.00
CIF	134478.4	700000.0	13500.0	155867.2	1.73	5.35	122.47	0.00
IND	11.58	19.77	5.66	2.82	0.77	3.71	20.14	0.00
URB	45.19	68.83	19.89	11.68	-0.26	2.71	6.51	0.02

Source: Author’s computation, (2025) E-View, 14

For the stock market variables their descriptive variables are discuss as follow:

GHGPC (Greenhouse Gas Emissions per Capita): The average greenhouse gas emissions per capita across the sample countries is 3.56 metric tons, with a maximum value of 11.86 and a minimum of 0.77, indicating wide disparities in emissions among Sub-Saharan African (SSA) countries. The standard deviation (3.10) is close to the mean, suggesting moderate variability. The positive skewness (1.37) and excess kurtosis (3.76) indicate a right-skewed and leptokurtic distribution, which is confirmed by the Jarque-Bera (J-B) statistic (56.59, $p < 0.01$), signifying non-normality. The high emission values in a few countries could be attributed to industrial and energy sector emissions, while most countries maintain low per capita emissions—consistent with SSA's historically low contribution to global GHG but increasing environmental vulnerability (World Bank, 2022).

BC_GDP (Bank Credit to the Private Sector as % of GDP); This variable, with a mean of 47.77%, indicates the degree of financial intermediation in SSA countries. The wide range—from 8.08% to 142.42%—and a high standard deviation (39.09) suggest considerable financial sector disparities among countries. A skewness of 0.75 and kurtosis of 2.24 signal a moderately skewed and mesokurtic distribution, again confirmed by the significant J-B statistic (19.69, $p < 0.01$). The level of credit provision is critical for capital formation and economic growth, but excessive credit without strong financial regulation may fuel carbon-intensive consumption and production (Tamazian & Rao, 2010; Mensah et al., 2023).

FINL (Financial Liquidity as % of GDP): With a mean value of 47.61% and a maximum of 159.95%, this reflects the extent of monetary assets relative to economic output. The skewness of 1.35 and high kurtosis of 4.75 show a concentration of countries with low liquidity and few outliers with highly liquid financial systems. The statistically significant J-B (72.86, $p < 0.01$)

underscores non-normality. Higher financial liquidity theoretically enhances investment, including green projects, but in SSA, it may also reflect inefficiencies or excess reserves due to underdeveloped financial intermediation.

TURN (Stock Market Turnover Ratio); the average turnover ratio of 9.44% reflects limited stock market activity across SSA, particularly when compared to developed economies where turnover often exceeds 100% of market capitalization. The high skewness (2.64) and extreme kurtosis (13.13) suggest that most countries have low turnover with a few outliers exhibiting higher liquidity. The significant J-B statistic (913.19, $p < 0.01$) confirms the non-normal distribution. These characteristics indicate illiquid and shallow stock markets with weak investor confidence, often associated with inadequate governance and market infrastructure (Beck & Levine, 2004).

VASTR (Stock Market Value Traded as % of GDP); This indicator, with a mean of 9.67%, suggests that stock trading as a proportion of GDP remains low in SSA, pointing to the underutilization of capital markets for corporate financing. The standard deviation (22.98) exceeds the mean, while the skewness (2.75) and kurtosis (10.06) further confirm market underdevelopment and concentration. A few countries with relatively active markets (e.g., South Africa, Nigeria) pull the average upward, but most remain underdeveloped. As stock markets become deeper and more efficient, they can support sustainable investment if green finance instruments are adopted (Scholtens & Zhou, 2008).

Further to the descriptive statistics, the initial patterns of interrelationships among the variables of the study are examined by considering the correlations matrix. The focus is on the relationships among the independent variables in order to observe structural leverages among the variables and also to determine possible presence of multicollinearity among the variables. The correlation matrix presented in Table 4.2 of your study offers important insights into the relationships among financial development, carbon financing, and carbon emissions in Sub-Saharan Africa (SSA). The relationship between greenhouse gas emissions (GHG) and bank credit to GDP is weak and statistically insignificant (0.061; $p = 0.435$), suggesting that expansion in private sector credit does not have a strong or direct effect on emission levels across SSA countries. This result may reflect the fact that credit expansion in the region is not necessarily directed toward high-emission sectors such as manufacturing or energy-intensive industries.

A more notable relationship is found between GHG and financial liquidity (FINL), where a statistically significant negative correlation (-0.379; $p = 0.000$) is observed. This implies that higher liquidity in the financial system is associated with lower levels of emissions. A plausible interpretation is that financially liquid economies might invest more in clean technologies or support service-oriented economic structures that produce fewer emissions. This finding aligns with the broader literature on the finance–environment nexus, which highlights the potential of liquidity to facilitate environmentally responsible investment.

Greenhouse gas emissions are positively correlated with stock market turnover (TURN) at 0.457 ($p = 0.000$), suggesting that greater stock trading activity is associated with higher emissions. This relationship may indicate that active capital markets facilitate investments in carbon-intensive industries. A similar and stronger correlation is observed between GHG and the value of stock market trades (VASTR) at 0.557, reinforcing the view that stock market development in SSA currently supports emission-generating activities. These findings suggest that capital market growth has not yet been aligned with green investment priorities in the region.

The correlation between GHG and certified emission reductions (CERS) is particularly strong at 0.876 ($p = 0.000$), highlighting that higher-emitting countries are more involved in international carbon credit projects. This is consistent with the operational logic of the Clean Development

Mechanism, which targets countries with measurable emission reduction potentials. Similarly, the relationship between GHG and climate investment funds (CIF) is high at 0.783, suggesting that countries with greater emissions or higher climate vulnerability attract more climate finance support. These results emphasize the responsiveness of international climate finance mechanisms to environmental pressures within SSA.

The most pronounced relationship in the matrix is between GHG and manufacturing value added (MVA), which stands at 0.962 ($p = 0.000$). This strong positive correlation underlines the role of manufacturing as a primary driver of emissions in SSA, reaffirming that industrial activities in the region remain heavily reliant on emission-intensive processes. Meanwhile, the relationship between GHG and urbanization (URB) is relatively weaker at 0.324 but still statistically significant, indicating that while urban expansion contributes to emissions, its effect is less prominent than that of industrial or financial factors.

Looking within the financial sector, the correlation between bank credit to GDP and financial liquidity is high at 0.709 ($p = 0.000$), confirming that SSA countries rely predominantly on bank-based financial systems. This reinforces the notion that monetary expansion in the region is closely tied to credit provision rather than capital market development. The relationships between bank credit and both stock market turnover (0.583) and value traded (0.684) are also moderate to strong, suggesting a complementary relationship between banking and stock markets. In SSA, financial deepening appears to support both banking and capital market functions, contradicting the view that these financial structures are substitutes.

In contrast, the relationship between financial liquidity and stock market variables is weak. The correlation between FINL and TURN is 0.168, and between FINL and VASTR is 0.245, both statistically significant but relatively low. This suggests that despite high levels of liquidity in some economies, this does not automatically translate into active stock market participation. This disconnect may be due to inefficiencies in the financial system or a lack of investor confidence in stock markets.

As expected, TURN and VASTR exhibit a strong correlation of 0.712, highlighting the interdependence between trading volume and market capitalization. Higher turnover typically leads to increased value traded, confirming the validity of these measures as proxies for capital market development.

Examining carbon financing more closely, the correlation between CERS and financial liquidity is weak and negative (-0.175), suggesting that deeper domestic financial systems are not directly linked to carbon credit activity. This is understandable given that most carbon projects in SSA are financed through international mechanisms rather than domestic credit. However, the moderate correlations between CERS and TURN (0.435) and VASTR (0.647) indicate that stock markets are more relevant platforms for carbon-related financial flows than banking institutions. Similarly, climate investment funds show moderate to strong correlations with bank credit (0.453), TURN (0.616), and VASTR (0.645), suggesting that countries with better-developed financial systems—especially capital markets—are more likely to attract international climate finance. This underscores the role of market-based finance in supporting climate-related investments in SSA.

Manufacturing value added also correlates strongly with CERS (0.851) and CIF (0.689), indicating that industrialized countries in SSA are key destinations for both emission reduction projects and climate investment funding. These relationships suggest that the manufacturing sector represents both the source of emissions and the focal point for mitigation financing in the region.

Urbanization, on the other hand, shows moderate positive correlations with most variables, ranging from 0.324 with GHG to 0.437 with TURN. This suggests that as countries become more urbanized, there is a general increase in economic and financial activity, albeit at a slower pace than seen with industrialization or capital market development.

Thus, from a multicollinearity standpoint, the correlation matrix indicates that although a few variables show strong associations (e.g., BC_GDP and FINL, TURN and VASTR), no pair exceeds the conventional threshold of 0.80, except MVA and GHG (0.962), which may warrant further diagnostic testing such as variance inflation factor (VIF) analysis. Therefore, multicollinearity is not expected to pose a significant issue in the regression models used in the study.

Table 4.2: Correlation Matrix

Variable	LGHG	BC_GDP	FINL	TURN	VASTR	LCERS	LCIF	LMVA	URB
GHG	1								
BC_GDP	0.061 (0.435)	1							
FINL	-0.379 (0.000)	0.709 (0.000)	1						
TURN	0.457 (0.000)	0.583 (0.000)	0.168 (0.030)	1					
VASTR	0.557 (0.000)	0.684 (0.000)	0.245 (0.001)	0.712 (0.000)	1				
CERS	0.876 (0.000)	0.259 (0.001)	-0.175 (0.024)	0.435 (0.000)	0.647 (0.000)	1			
CIF	0.783 (0.000)	0.453 (0.000)	-0.044 (0.568)	0.616 (0.000)	0.645 (0.000)	0.715 (0.000)	1		
MVA	0.962 (0.000)	0.005 (0.949)	-0.371 (0.000)	0.407 (0.000)	0.544 (0.000)	0.851 (0.000)	0.689 (0.000)	1	
URB	0.324 (0.000)	0.376 (0.000)	0.035 (0.657)	0.437 (0.000)	0.595 (0.000)	0.417 (0.000)	0.468 (0.000)	0.435 (0.000)	1

Source: Author's computation (2025) E-View, 14

4.3 Tests of Time Series and Cross-sectional Properties of the Panel Data

4.3.1 Test for Cross-sectional Dependence of the Panel Data

The panel structure of the dataset employed in this study present the challenge of heterogenous characteristics of the dataset. This is manifested in terms of the likely presence of correlations in the errors within the cross-sections of the panel (Baltagi et al, 2012). The "presence of these correlations increases the standard errors of the estimates and reduces the efficiency of regression results" (Wooldridge 2010). The variables of focus in the study are those that may exhibit cross sectional correlations. For instance, carbon emissions trends among SSA countries are likely to exhibit similar basic characteristics since these economies are at similar level of development and industrial base. The industrial and other economic activities are expected to generate similar patterns of greenhouse gas emissions. In the same vein, the level of financial sector performance of most countries in SSA countries (except South Africa) exhibit are driven by common domestic and regional patterns. These issues imply that estimation of relationship among the variables may demonstrate underlying common relationships across the countries. Thus, the problem of cross-sectional dependence, which is correlated errors across cross-sections of panel data, may be expected in the dataset used for our analysis.

In this study, the problem and presence of cross-sectional dependence is investigated by implementing the Pesaran (2004) cross-sectional dependence (CD) test. The null hypothesis for the cross-sectional dependence test is the absence of cross-sectional dependence, suggesting that it is expected that the coefficients fail the significance test in order to establish the absence of cross-sectional dependence. The results of the CD tests for both Equations specified for the study are presented in Table 4.3.

Table 4.3: Cross-section Dependence Test Results

Variable	CD	test –p	corr – abs(corr)
GHG	152.8	0.00	0.51
BC_GDP	14.31	0.00	0.31
FINL	275.7	0.00	0.65
TURN	184.0	0.00	0.58
VASTR	243.7	0.00	0.75
LCERS	12.00	0.02	0.15
LCIF	39.96	0.00	0.21
LMVA	134.4	0.00	0.45
URB	19.40	0.00	0.28

Source: Author's computation (2025) E-View, 14

Table 4.4 presents the results of the cross-sectional dependence (CD) tests for all variables used in the study, offering insights into whether shocks in one Sub-Saharan African (SSA) country could systematically affect others. The CD test, developed by Pesaran, evaluates whether residuals across cross-sectional units are correlated. This is crucial in panel data analysis, as the presence of cross-sectional dependence implies that conventional panel estimators like fixed and random effects may produce inefficient or biased results if the interdependence is not accounted for.

For greenhouse gas emissions per capita (GHG), the CD test statistic is 152.8 with a p-value of 0.00, and an average absolute correlation of 0.51. This indicates strong cross-sectional dependence, suggesting that emission trends in one SSA country are significantly related to others, possibly due to regional climate exposure, similar energy structures, or policy diffusion. The implication is that environmental shocks or policy shifts in a single country could ripple across others in the region.

In the case of bank credit to the private sector as a percentage of GDP (BC_GDP), the CD test statistic of 14.31 and a p-value of 0.00, along with a correlation of 0.31, indicates moderate but statistically significant interdependence. This suggests that regional financial developments, banking reforms, or shared access to development finance institutions could influence credit flows across countries. Similarly, financial liquidity (FINL) shows an exceptionally high CD test statistic of 275.7, with an average absolute correlation of 0.65. This reflects systemic interlinkages in financial liquidity conditions across the region, possibly driven by shared monetary regimes, external aid inflows, or parallel banking sector constraints.

Stock market turnover (TURN) records a CD test of 184.0 and a correlation of 0.58, indicating robust dependence across countries. This result is consistent with the observation that SSA capital markets are shallow and often influenced by regional investor behavior or macroeconomic shocks. Likewise, the value of stock traded (VASTR) shows even stronger dependence with a CD statistic of 243.7 and a correlation of 0.75. This suggests that capital market dynamics in one SSA country—especially those with relatively large markets like South Africa—may significantly influence the performance of others. These results underscore the need for financial market models that account for interconnectedness in the region.

For certified emission reductions (LCERS), the CD test statistic is 12.00 with a p-value of 0.02 and a lower correlation of 0.15. This suggests weaker but still significant interdependence, likely reflecting the concentration of carbon market activity in a few SSA countries, such as South Africa and Kenya. Despite the limited participation, the spillover effects of carbon pricing policies and climate negotiations are still present. Climate investment funds (LCIF) similarly show moderate dependence, with a CD test of 39.96 and a correlation of 0.21. This reflects how international donor strategies and regional climate vulnerability assessments may simultaneously influence funding decisions across multiple countries.

Manufacturing value added (LMVA) shows significant cross-sectional dependence, with a CD test of 134.4 and a correlation of 0.45. Industrial development in SSA appears to move in tandem across countries, possibly due to similar economic development strategies, trade linkages, and shared infrastructure initiatives. Urbanization (URB) also shows statistically significant dependence, with a CD test of 19.40 and an average correlation of 0.28. This indicates moderate synchronization of urban expansion across SSA, which could result from regional demographic trends, migration patterns, and parallel urban planning policies.

Overall, the consistently significant CD test statistics across variables confirm the presence of cross-sectional dependence in the dataset. This finding implies that the traditional first-generation panel methods, which assume cross-sectional independence, are inappropriate for the data. Therefore, the study correctly proceeds with panel estimation techniques that account for this interdependence, such as second-generation unit root and cointegration tests, panel-corrected standard errors, and estimation models that adjust for common shocks and spillovers. By acknowledging and incorporating cross-sectional dependence, the study ensures that its statistical inferences and policy implications remain robust and reflective of regional dynamics in SSA.

4.3.2 Panel Unit Root and Cointegration Tests

It is also crucial to test for the level of stationarity and long run dependence of the panel data used in this study. Hence, the tests for unit root or test for level of stationarity of data are also performed for the variables in the study. Panel data unit root tests that consider both the homogenous-character (i.e., the Levin, Lin and Chu (LLC)), and the heterogenous-character (i.e., Imp, Pesaran and Shin (IMP)) of the panel dataset are adopted. The tests results are presented in table 4.5. From the Table, the test statistics for some of the variables fail the significance at the 5 percent level for the variables in levels. The test statistics of these variables however become significant after taking their first differences. This shows that these variables are integrated of order one since they are stationary only after first differencing. The other variables in the Table are stationary at level. Thus, there is a mixed structure of unit roots among that dataset.

Table 4.4: First Generation Unit Root Test Result

Variable	*Levin, Lin, and Chu*				*Im, Pesaran, and Shin W-stat*				Order
	Level		**First diff**		**Level**		**First diff**		
	stat.	***prob.***	***stat.***	***prob.***	***stat.***	***prob.***	***stat.***	***prob.***	
GHG	-0.91	0.17	0.75	0.77	-4.27	0.00	-5.01	0.00	I(1)
BC_GDP	-1.17	0.12	-5.54	0.00	-2.52	0.00	-6.52	0.00	I(1)
FINL	-0.03	0.72	-2.74	0.01	-1.62	0.05	-5.22	0.00	I(1)
TURN	-3.73	0.00	-8.98	0.00	-3.59	0.00	-9.49	0.00	I(0)
VASTR	-1.96	0.02	-7.78	0.00	-1.83	0.02	-8.16	0.00	I(0)
LCERS	0.77	0.77	-1.76	0.03	3.76	0.99	-1.85	0.03	I(1)
LCIF	-0.26	0.39	4.28	0.00	1.89	0.97	-7.11	0.00	I(1)
LMVA	-1.11	0.13	-5.99	0.00	1.02	0.84	-5.26	0.00	I(1)
URB	-2.29	0.01	-24.9	0.00	-4.86	0.00	-14.11	0.00	I(0)

Source: Author's computation (2025) E-View, 14

The presence of cross-sectional dependence in the data suggests that the first-generation unit root tests above may not fully capture the level of stationarity of the data. In general, applying methods that account not only for the time-series dimension but also for the cross-sectional dimension provides increased power of prediction for estimation with panel data. Thus, we report the results of the second-generation test of unit root based on the Cross-sectionally augmented Im-Pesaran-Shin (CIPS) procedure. This method of unit root test accounts for cross-sectional dependence in the panel data. The result reported in Table 4.5 shows that the integration order of the variables are mixed with some variables integrated at order zero (I(0)) and others integrated at order one (I(1)). Interestingly the PMG estimation framework adopted in this study is effective in estimating error correction functions with variables that are integrated of different orders.

Table 4.5: Second Generation Unit Root Test Result (CIPS)

Variable	Level			First diff.		Order of Integration
	stat.	5% crit. val.		stat.	5% crit. val.	
GHG	-1.376	-2.34		-2.86	-2.34	I(1)
BC_GDP	-0.864	-2.34		-3.937	-2.34	I(1)
FINL	-2.762	-2.34		-4.113	-2.34	I(0)
TURN	-2.195	-2.34		-3.661	-2.34	I(0)
VASTR	-1.083	-2.34		2.455	-2.34	I(1)
LCERS	-3.596	-2.34		-4.659	-2.34	I(0)
LCIF	1.620	-2.34		2.498	-2.34	I(1)
MVA	-1.281	-2.34		-4.665	-2.34	I(1)
URB	-2.340	-2.34		-5.023	-2.34	I(0)

Source: Author's computation (2025) E-View, 14

The results of cointegration tests for the three Equations of the study are presented in Table 4.6. Both the Pedroni and Kao panel cointegration tests are conducted on the basis of the goal of the analysis. While the Pedroni test is specific in terms of the heterogeneity assumptions, the Kao test considers the random relationships over the cross-sections of the data (Wooldridge, 2010). The results of the within-group tests and the between-group tests show that the null hypothesis of no cointegration can be rejected for the each of the equations at the 5 percent level. This is based on the Panel PP and the Panel ADF statistics. The cointegration test results imply that there is cointegration among the variables for each of the three Equations in the study. Essentially, this test establishes a significant long run relationship among the variables in each of sustainable development equations. The results of the Pedroni tests are also corroborated by the Kao tests which show significant coefficients that indicate that cointegration exists among the variables.

Table 4.6: First Generation Cointegration Test Result

Test	*H1: common coefs. (within-dimension)*				*H1: individual coefs. (between-dimension)*	
	t-Stat.	**Prob.**	**W- t-stat.**	**Prob.**	**t-stat.**	**Prob.**
Model: with financial market						
rho-Stat.	0.288835	0.6136	-0.190666	0.4244	1.401204	0.9194
PP-Stat.	-2.069207	0.0193	-3.615030	0.0002	-2.269828	0.0116
ADF-Stat.	-1.973370	0.0352	-2.107183	0.0176	-2.277125	0.0114
Kao	-7.18 (0.00)					
Model: with stock market						
rho-Stat.	0.476601	0.6832	0.677286	0.7509	1.967043	0.9754
PP-Stat.	-1.719906	0.0471	-1.782585	0.0418	-0.554161	0.2897
ADF-Stat.	-1.118589	0.1317	-1.915536	0.0277	-1.703293	0.0464
Kao	-2.71 (0.03)					
Model: with climate funds						
rho-Stat.	0.899716	0.8159	1.074771	0.8588	2.153494	0.9844
PP-Stat.	-1.384519	0.0831	-1.342375	0.0897	-3.071306	0.0011
ADF-Stat.	-2.278370	0.0114	-2.435919	0.0074	-3.055014	0.0011
Kao	-6.19 (0.00)					

Source: Author's computation (2025) E-View, 14

The second generation cointegration tests are also reported. The second-generation test for cointegration takes into account cross-sectional dependencies which have been established by the cross-sectional test. The result of the second generation cointegration test is therefore used in addition to the first-generation test above. In this case, the Westerlund cointegration test is conducted. The results for the three equations of the study are presented in Table 4.7 It should be noted that the G_t and G_α report the group-mean tests, while P_t and P_α represent the panel tests. The *G* tests are designed to test the alternative hypothesis that at least one unit is cointegrated, while the P statistics test the alternative that the panel is cointegrated as a whole. The null hypothesis of the Westerlund test is "no cointegration". In the model with climate fund variables, both the *G* and *P* statistics reject the null hypothesis of no cointegration which shows clear cointegration and long run relationship among the variables. For the model with financial development, only the G_t statistics did not support cointegration, while only the G_α statistic did not support cointegration. In all, the Westerlund second-generation cointegration test shows that there is cointegration among the variables in the regression models.

Table 4.7: Second Generation Cointegration Test Result (Westerlund)

Statistic	*Model: with fin dev*		*Model: with cap. Mkt*		*MODEL: with climate fund*	
	Value	***Robust P-value***	***Value***	***Robust P-value***	***Value***	***Robust P-value***
G_t	-1.121	0.25	-2.732	0.00	-2.833	0.00
G_a	-4.276	0.00	-1.146	0.34	-3.944	0.00
P_t	-4.326	0.00	-4.326	0.00	-7.002	0.00
P_a	-2.947	0.00	-3.089	0.00	-5.384	0.00

Source: Author's computation (2025) E-View, 14

4.4 Regression Analysis

The analysis of the regression results for the estimated models specified in the previous chapter is performed in this section. The PMG regression analysis is performed for the panel of seven SSA countries for the period of 24 years, which implies that both the short-run and the long run relationships are determined. Note that the optimal lag length for estimating the PMG analysis was selected using both the Akaike Information criterion (AIC) and the Schwarz Information criterion (SIC). Both of the criteria indicated that the lag length of one is optimal for estimating the panel data relationship.

4.4.1 Regression Results for the Effects of Financial Development and Carbon Finance on Carbon Emissions

The result of the PMG estimates for the complete model that contains all the variables that capture financial market depth, capital market performance and climate funds are presented in Table 4.8. Given that the PMG results are reported, the goodness of fit statistics (including R-squared and F-statistics) are not estimated since the means of the cross-sections are pooled over the time series. The long-run estimates are presented in the upper panel of the Table. The coefficient of bank credit to GDP ratio (BC_GDP) is significant and positive, while that of financial liquidity fails the significance test. It shows that an increase in bank credit to GDP leads to higher GHG emissions while increased financial depth has no effect.

The coefficient of stock market turnover (TURN) is also insignificant in the model and indicates that market turnover or the speed of trading in the stock market does not affect carbon emissions in SSA. Value traded in stock market (VASTR) is also shown to have an insignificant effect on emissions since the coefficient fails the significance test at the 5 percent level. Thus, stock market value traded does not have a strong or consistent effect on emissions in the long run. The coefficient of certified emission reduction units (CERS) is significant in the model and negative. This shows that certified emission reduction units significantly reduce GHG emissions. Also, the coefficient of climate investment funds (CIF) is significant and negative suggesting that higher climate investment funds (CIF) lead to a significant reduction in emissions.

Table 4.8: PMG Estimation

Variable	**Coeff.**	**t-Stat.**	**Prob.**
Long Run Equation			
BC_GDP	0.011	2.940	0.004
FINL	0.005	1.262	0.210
TURN	0.006	1.648	0.103
VASTR	-0.002	-0.537	0.592
LCERS	-0.090	-5.229	0.000
LCIF	-0.403	-4.085	0.000
LMVA	1.189	6.502	0.000
URB	0.011	0.951	0.344
Short Run Equation			
ECM_{t-1}	-0.204	-1.740	0.050
ΔBC_GDP	-0.004	-1.120	0.266
ΔFINL	0.002	0.730	0.467
ΔTURN	0.002	0.996	0.322
ΔVASTR	-0.013	-2.061	0.042
ΔLCERS	-0.021	-0.681	0.498
ΔLCIF	-0.044	-0.550	0.584
ΔMVA	-0.097	-0.356	0.722
ΔURB	0.246	1.407	0.163
Constant	-2.307	-1.907	0.060

Source: Author’s computation (2025) E-View, 14

The estimates of the short-run equation are reported in the lower panel of Table 4.8. The short-run equation captures the immediate (transitory) effects of changes in the independent variables on emissions. The coefficient of the error correction term is negative and just passes the significance test at the 5 percent level. The negative and significant ECM coefficient indicates the presence of a stable long-run relationship. The speed of adjustment is 20.4%, meaning that deviations from the long-run equilibrium are corrected by about 20% in each period. The coefficient of BC_GDP is insignificant in the short run estimates, indicating that in the short run, changes in bank credit to GDP do not have a significant impact on emissions. Also, the result for FINL indicates that financial liquidity does not significantly affect emissions in the short run in SSA.

The coefficient of TURN also fails the test and indicates that stock market turnover has no immediate impact on emissions. Only the coefficient of VASTR is significant in the short run estimates among the relevant variables. This shows that unlike in the long run, value traded in the stock market has a significant short-run negative effect on emissions. This may indicate that short-term fluctuations in market activity lead to temporary emission reductions. The coefficients of both CERS and CIF fail the significance test at the 5 percent level. This shows that in the short run, changes in CER units do not significantly impact emissions. Also, climate investments take time to yield noticeable emission reductions in SSA.

The models for the study are further estimated in a recursive form by using variables for financial development, stock market trading, and climate funding separately in each equation. The results are presented in Table 4.9. Only the long run (stable) estimates are reported since they are the more reliable estimates in relation to clime change issues. In the equation that uses only financial development variables the coefficients indicate important outputs. The result shows that a statistically significant positive relationship exists between bank credit and greenhouse gas emissions (GHG). This is in line with the complete estimates reported in Table 4.8. It shows that as bank credit increases in the economy, carbon emission also increases. Thus, the result shows that irrespective of the factors taken into consideration in the empirical analysis, credit penetration has a clear positive impact on carbon emissions among SSA countries. The coefficient of financial liquidity is insignificant in the recursive estimates and shows that financial liquidity (depth) has no direct impact on emissions in SSA. The coefficients of manufacturing value added and urbanization rate are both positive and significant in the equation. This shows that increases in manufacturing output lead to higher emissions while urban centre growth also increase carbon emission in SSA. The error correction term in the model has the correct sign and significance, indicating weaker long-term correction toward equilibrium.

Table 4.9: Recursive (Separate) Estimation Results (Long Run)

Variable	*Financial development*			*Capital market*			*Climate funds*		
	Coeff.	**t**	**Prob.**	**Coeff.**	**t**	**Prob.**	**Coeff.**	**T**	**Prob.**
BC_GDP	0.011	2.43	0.015						
FINL	0.000	0.17	0.866						
TURN				-0.002	0.27	0.784			
VASTR				-0.039	2.06	0.039			
LCERS							0.001	0.14	0.891
LCIF							-0.325	3.90	0.000
LMVA	0.082	2.41	0.016	0.526	3.92	0.000	0.801	3.93	0.000
URB	0.066	3.93	0.000	-0.042	3.91	0.000	-0.022	3.92	0.000
ECM_{t-1}	-0.236	1.63	0.102	-0.228	2.43	0.015	-0.427	2.51	0.012

Source: Author’s computation (2025) E-View, 14

The result for the separate effects of the stock market trading/performance factors is shown in the second panel of Table 4.9. The coefficient of stock market turnover is insignificant, while that of Value Traded in Stock Market is significant and negative. This shows that turnover (trading frequency) in stock markets does not directly impact emissions. On the other hand, higher stock market activity (in terms of traded value) is associated with lower emissions. Both manufacturing value added and urbanization rates are significant in the result.

The result for the climate funds equation also reveals that the effect of CERS on carbon emissions is statistically insignificant, implying that CER mechanisms alone may not have a measurable effect on emissions. On the other hand, climate investment funds (LCIF) have a strong negative and highly significant effect on emissions. This shows that increased climate funds significantly reduce emissions. Again, the coefficients of MVA and URB are significant in the equation. The error correction term is negative and significant at 5 percent. This indicates a strong and significant adjustment speed, indicating that deviations correct by 42.7% per period, suggesting a robust long-run equilibrium process.

4.4.2 Robustness Checks – Estimation of Panel Correlated Standard Errors Equations

The results of the cross-sectional dependence test have shown that the cross-sections in the panel data are serially correlated, which indicates that the application of the PMG analysis may yield inefficient coefficient estimates. In order to test the robustness of the PMG regression results, we apply the panel correlated standard errors (PCSE) estimation procedure on the models. The aim is to determine whether the estimated coefficients and standard errors differ significantly from the PMG results. The result of the PCSE estimation for the complete Equation is presented in Table 4.12. The results of the long run estimates of the complete model are presented in Table 4.10. It can be seen that the coefficients of the PCSE estimates perform better in terms of significance level than in the PMG estimates. This justifies the application of the standard error estimation framework.

The adjusted R-squared value for the estimates is high in the model and shows that the model has a high explanatory capacity. In the result, the coefficient of bank credit to GDP ratio is significant and positive, which is in line with is in line with the PMG estimates (in terms of signs). This result shows that credit penetration significantly promotes carbon emissions in SSA countries. The coefficient of financial liquidity is also significant, but negative. This shows that financial depth in the economy reduces emissions. The result also shows that value traded in the stock market significantly promotes emissions, while climate investment funds reduce emissions. The effects of CERs and market turnover are shown to be insignificant in the complete model result.

Table 4.10: PCSE Estimation Results (Long Run) – Robustness Check

Variable	**Coefficient**	**t-Statistic**	**Prob.**
Constant	-8.207	-29.093	0.000
BC_GDP	0.004	3.662	0.000
FINL	-0.007	-6.175	0.000
TURN	-0.002	-1.388	0.167
VASTR	0.004	2.964	0.004
LCERS	-0.019	-1.356	0.177
LCIF	-0.423	-14.160	0.000
LMVA	1.030	40.110	0.000
URB	-0.028	-24.670	0.000
Adj. R-sq.	0.986		
F-stat.	1482.8		

Source: Author's computation (2025) E-View, 14

The recursive estimates of the relationships along the path of individual effects are also estimated and reported in Table 4.11. These are the most efficient estimates since they provide robust standard errors that cover the problems of cross-sectional correlations in the initial PMG estimates. These estimates also show the direct effects of the three different categories (financial development, stock market, and climate funding) on carbon emission in SSA. As noted earlier, the long-run equation explains the long-term impact of the independent variables on greenhouse gas emissions and is thus more stable. These are the coefficients also reported in Table 4.11. The results report impressive goodness of fit indicators. The adjusted R-squared for each of the equations is high and shows that at least 97 percent of the variations in carbon emissions in SSA were explained in each equation.

Table 4.11: Recursive (Separate) Estimation Results (Long Run) – Robustness Check

Variable	*Financial development*			*Capital market*			*Climate funds*		
	Coeff.	**T**	**Prob.**	**Coeff.**	**t**	**Prob.**	**Coeff.**	**t**	**Prob.**
Constant	-6.089	-3.91	0.000	-6.789	- 3.95	0.000	-9.532	-3.99	0.000
BC_GDP	0.010	3.90	0.000						
FINL	-0.010	-3.89	0.000						
TURN				0.012	3.90	0.000			
VASTR				0.005	3.29	0.001			
LCERS							-0.015	-0.92	0.360
LCIF							-0.478	-3.91	0.000
LMVA	-1.275	-3.95	0.000	-1.342	-3.92	0.000	-1.077	-3.90	0.000
URB	-0.027	-3.91	0.000	-0.028	-3.91	0.000	-0.025	-3.89	0.000
Adj. R-sq.	0.970			0.973			0.989		
F-stat.	1361.9			1500.3			3713.8		

Source: Author's computation (2025) E-View, 14

In the financial development equation, the coefficient of bank credit to GDP ratio is positive and significant at the 1 percent level. This shows that an increase in bank credit to GDP leads to higher GHG emissions in SSA. This suggests that financial development through increased bank credit could be facilitating economic activities that contribute more to emissions in the region. A one percent increase in credit penetration in SSA leads to a 0.01 percent rise in carbon emission for the region. The coefficient of financial liquidity (FINL) is negative and significant at the 5 percent level. This shows that financial liquidity, which represents financial depth, tends to significantly reduce carbon emission in SSA. Thus, while credit penetration increases carbon emission, financial depth directly mitigates such emissions in SSA.

In the stock market result, the coefficients of both stock market turnover (TURN) and value traded ratio (VASTR) are significant and positive. This shows that both stock market factors significantly increase carbon emission in SSA. The positive coefficient of TURN suggests that an increase in stock market turnover may lead to higher emissions, potentially due to increased investment activity in emission-intensive sectors. The significant positive effect of value traded ratio suggests that stock market value traded promotes activities that lead to increases in carbon emissions in SSA.

The Table also shows results for the climate fund variables. The coefficient of certified emission reduction units (CERS) fails the significance test in the equation even at the 5 percent level. This shows that changes in the certified emission reduction (CER) units do not affect the patterns of carbon emission in SSA. In essence, CER units do not provide carbon offset mechanisms that help to mitigate emissions in SSA. On the other hand, the coefficient of climate investment funds (CIF) is significant at the 1 percent level and negative. This shows that higher climate investment funds (CIF) lead to a significant reduction in emissions. This highlights the effectiveness of climate-related financing in promoting cleaner energy and sustainable projects. In each of the equations, there is strong evidence that manufacturing value added and urban rate both promote carbon emissions in SSA.

4.5 Individual's Country Analysis

In this section, the panel data in the study was disaggregated into the several countries included in the analysis and the relationships between financial development, carbon financing and carbon emission were examined for the respective countries. This helps to provide a broader and more country-specific view about the leading factors that drive carbon financing and carbon emission for the respective countries. It should be noted that seven countries were included in the panel data analysis.

In order to further improve on the robustness of the estimates in the study, the individual relationships for each of the countries are estimated and the results are presented in Table 4.12. Fusing on the long run and stable estimates, the results show that bank credit to GDP exhibits a positive and significant impact on emissions in Cote d'Ivoire which suggests that increased banking sector depth contributes to higher environmental degradation in the country. However, the coefficient of bank credit shows negative but insignificant effects in Kenya, Mauritius, Namibia, and Nigeria. This indicates that bank credit has limited effect on greenhouse gas emission in the long run for most of the countries. Financial liquidity generally has a negative association with emissions for most of the countries. This effect is more pronounced for Cote d'Ivoire which implies that broader money supply may support greener investments or efficiency improvements. Stock market turnover is shown to positively affect emissions in Cote d'Ivoire but is largely insignificant in other countries, while value traded in the stock market tends to reduce emissions in Cote d'Ivoire (-0.202, 0.024), Kenya and Namibia in the long run. This result highlights the potential channels for equity markets to fund sustainable projects.

In terms of the clime funding variables, the coefficients of certified emission reduction units and climate investment funds both display varied long-run impacts on emissions. LCERS shows negative but insignificant effects in most countries except for a near-significant negative in Ghana and Nigeria (-0.327, 0.062). This shows that carbon credit mechanisms could mildly curb emissions by incentivizing reductions in individual countries. LCIF demonstrates stronger emission-reducing potential with significant negative coefficients in Cote d'Ivoire, Mauritius, Namibia and Nigeria. This shows that targeted climate funds effectively support mitigation efforts in most SSA countries. Overall, the models for each of the countries fit well with adjusted R-squared values ranging from 0.735 to 0.966. This result affirms robust long-run relationships in terms of the explanation of greenhouse gas emissions.

Table 4.12: Disaggregated Results for Individual Countries

Variable	*Cote d'Ivoire*		*Ghana*		*Kenya*		*Mauritius*		*Namibia*		*Nigeria*		*South Africa*	
	Coeff.	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**
Short run														
D(BC_GDP)	0.004	0.037			-0.029	0.000	0.000	0.420			0.000	0.924	-0.001	0.007
D(FINL)	0.001	0.262									0.000	0.805	0.002	0.002
D(TURN)							0.001	0.708	0.000	0.239			0.000	0.809
D(VASTR)	-0.097	0.000			0.051	0.000			-0.105	0.008				
D(LCERS)			0.101	0.021	-0.295	0.000	-0.122	0.009			-0.215	0.001		
D(LCIF)	-0.102	0.002							0.315	0.000	-0.353	0.000		
D(MVA)	0.172	0.003							0.161	0.093	-0.077	0.227		
D(URB)	0.087	0.000									-2.573	0.000	1.618	0.000
ECM_{t-1}	-0.816	0.000	-0.646	0.000	-0.963	0.000	-0.843	0.000	-1.024	0.000	-1.147	0.000	-0.661	0.000
Long run														
BC_GDP	0.024	0.048	0.009	0.169	-0.024	0.106	-0.002	0.050	-0.015	0.113	-0.008	0.077	0.001	0.717
FINL	-0.015	0.013	-0.004	0.446	0.044	0.076	0.000	0.457	0.001	0.535	0.003	0.519	-0.001	0.505
TURN	0.036	0.004	0.000	0.993	-0.008	0.583	-0.013	0.161	0.002	0.193	0.000	0.860	0.002	0.473
VASTR	-0.202	0.024	-0.005	0.955	0.083	0.008	-0.030	0.114	-0.329	0.051	-0.016	0.167	0.000	0.932
LCERS	-0.012	0.601	-0.175	0.089	-0.033	0.512	0.088	0.202	0.020	0.385	-0.327	0.062	-0.077	0.553
LCIF	-0.314	0.053	0.098	0.430	-0.011	0.932	-0.226	0.049	0.484	0.018	-0.428	0.006	-0.106	0.522
MVA	0.000	0.310	0.317	0.345	-0.273	0.641	0.486	0.016	-0.443	0.256	0.270	0.097	0.644	0.044
URB	0.149	0.001	0.085	0.007	0.146	0.014	-0.340	0.000	0.009	0.440	0.045	0.035	0.022	0.446
C	-0.684	0.134	-2.905	0.226	2.644	0.523	13.896	0.002	0.311	0.859	12.825	0.000	-0.517	0.890
R-squared	0.975		0.747		0.808		0.855		0.901		0.927		0.851	
Adj. R-sq.	0.966		0.735		0.777		0.832		0.879		0.899		0.818	

4.6 Test of Hypotheses

The hypotheses of the study are tested based on the estimated long run results from the PMG. The long estimates are the most stable and reliable as demonstrated in Chovancova et al (2024).

Hypothesis One:

There is no significant relationship between financial liquidity and carbon emission (measured by total greenhouse gas emissions (GHG)) in the Sub-Sahara Africa

In order to test the first hypothesis, the focus is on the coefficient of the long run estimate of FINL in the results in Table 4.10. The coefficient is 0.005 ($p > 0.05$). This shows that the coefficient fails the significance test at the 5 percent level. Based on this outcome, the null hypothesis cannot be rejected in this case. Thus, the results show that there is actually no significant relationship between financial liquidity and carbon emission (measured by total greenhouse gas emissions (GHG)) in the Sub-Sahara Africa. The results from the recursive estimates also support this outcome. Thus, there is evidence that financial liquidity does not affect the emission of carbon in the economies of SSA.

Hypothesis Two:

Banks' credits to GDP does not significantly affect carbon emission in the Sub-Sahara Africa

The test of this hypothesis is full result presented in Table 4.10 based on the long run estimate of the coefficient of BC_GDP. In the result, the coefficient is 0.011 ($p < 0.01$). This result shows that the coefficient passes the significance test at the 1 percent level. Thus, bank credit ratio is a significant factor in explaining carbon emissions among SSA countries. The null hypothesis is therefore rejected which implies that banks' credits to GDP significantly affects carbon emission in the Sub-Sahara Africa. In particular, the result reveals that the depth of bank credit in the economy tends to increase carbon emissions. The result from the recursive estimates corroborates the one of the full estimates.

Hypothesis Three:

Value of stock traded has no significant effect on carbon emission in the Sub-Sahara Africa

The test of this hypothesis is based on the long run estimate of the coefficient of VASTR in Table 4.10. In the result, the coefficient is 0.006 ($p > 0.05$). This result shows that the coefficient failed the significance test even at the 5 percent level. The null hypothesis is therefore accepted which implies that value of stock traded has no significant effect on carbon emission in the Sub-Sahara Africa. The results however revealed that when the other financial development factors are not accounted for (the recursive estimates), the impact of VASTR on carbon emissions is negative and significant at the 5 percent level. Essentially, the study has demonstrated that under a prevalent stock market in the financial sector of an economy, value traded does actually have a significant negative effect on carbon emissions in SSA.

Hypothesis Four:

There is no significant relationship between stock market turnover and carbon emission in the Sub-Sahara Africa

In order to test this hypothesis, the focus is on the long coefficient of TURN in the results in Table 4.10. The coefficient is 0.006 ($p > 0.01$). This shows that the coefficient of TURN also failed the significance test at even at the 5 percent level. Based on this outcome, the null hypothesis is accepted for this case. Thus, it is demonstrated that there is actually no significant relationship between stock market turnover and carbon emission in the Sub-Sahara Africa. The results from the recursive estimates also support this outcome.

Hypothesis Five:

Certified emission reduction (CER) unit has no significant relationship with carbon emission in the Sub-Sahara Africa

The test of the fifth hypothesis is based on the results in the long run for the coefficient of CER in the results reported in Table 4.1. The coefficient if -0.09 ($p < 0.01$), which shows that the coefficient passed the significance test at the 1 percent level. Based on this outcome the null hypothesis is rejected for the case of certified emissions reduction. This implies that certified emission reduction (CER) unit has a significant negative relationship with carbon emission in the Sub-Sahara Africa. Although this negative and significant impact does not persist when financial development is not accounted for (recursive estimates), the result shows clear evidence that CER significantly reduces carbon emissions in SSA.

Hypothesis Six:

There is no significant relationship between climate investment funds (CIF) and carbon emission in the Sub-Sahara Africa

The test of the final hypothesis is based on the long run estimate of the coefficient of CIF in Table 4.10. In the result, the coefficient is -0.403 ($p < 0.01$). This result shows that the coefficient passed the significance test even at the 1 percent level. The null hypothesis is therefore effectively rejected which there is actually a significant negative relationship between climate investment funds (CIF) and carbon emission in the Sub-Sahara Africa. This result remains the same even in the recursive estimates. Essentially, the study has demonstrated that climate funding effectively limits carbon emissions in SSA countries.

The summary of the hypotheses test outcomes on the basis of the 5 percent significance level are presented in Table 4.13.

Table 4.13: Summary Hypotheses Test Results

Hypothesis	**Decision (0.05 level)**	**Conclusion**
No significant relationship between financial liquidity and carbon emissions	Accept	Financial liquidity does not influence carbon emissions
Banks' credit to GDP does not significantly affect carbon emissions	Reject	Bank credit increases carbon emissions
Value of stock traded has no significant effect on carbon emissions	Partial reject	Stock market value decreases carbon emissions under certain conditions
Stock market turnover has no significant relationship with carbon emissions	Accept	Turnover does not affect carbon emissions
Certified Emission Reduction (CER) units have no significant relationship with carbon emissions	Reject	Negative and significant effect of CER units on carbon emissions
Climate investment fund (CIF) has no significant relationship with carbon emissions	Reject	CIF reduces carbon emissions

Source: Authors computation, 2025, (E-View, 14)

4.7 Discussion of Findings

The findings from the empirical analysis of the study provide important areas for emphasis in line with previous studies and in terms of implications. First, the study has found a divergent impact of financial development components on environmental outcomes among SSA countries. The study found that the level of financial liquidity significantly reduces long run carbon emission for the countries, while the level of credit penetration in the economies tends to increase carbon emissions. At first glance, these findings appear to be contradictory since both variables are expected to capture the level of financial sector development in a country. The findings from the study however demonstrate outcomes associated with allocation of financial resources (Alom et al., 2017; Wu, 2018; Rehmam et al., 2023). Specifically, financial liquidity represents the overall ease of accessing capital in an economy. This implies that it benefits a wider range of industries, including those investing in sustainable growth. On the other hand, private sector credit represents direct financing to businesses, and since SSA's private sector is dominated by low adherence to climate responsibility, more credit naturally leads to increased emissions. Thus, the result demonstrates that financial development is not inherently green or climate-damaging. Rather, it depends on how financial institutions and businesses utilize available funds.

The findings of a negative relationship between financial depth or financial liquidity and carbon emissions for SSA countries suggests that financial depth enables green investments and enhances access to funds for energy-efficient technologies. This result is in line with findings by Nasreen et al. (2017), Emenekwe, et al. (2022), Xuezhou, et al. (2022) and Nwabueze, et al. (2023) which suggest that financial depth tends to reduce carbon emissions both for developing and advanced economies. Specifically, when firms and individuals have better access to financial resources, they may be more likely to invest in renewable energy and low-carbon production methods. This outcome suggests that financially liquid economies enable businesses and individuals to access credit for energy-efficient technologies, cleaner production processes, and renewable energy projects. In the same vein, liquidity allows financial institutions to diversify their portfolios and fund green projects rather than relying solely on short-term, high-emission industries like fossil fuels or mining. As Zhout et al. (2023) also noted, high financial liquidity in the economy incentivizes firms to invest more resources in R&D and innovations for low-carbon technologies. This directly contributes to long-term emission reductions.

On the other hand, the study finds that higher bank credit to GDP tends to exacerbate carbon emissions in SSA countries. This indicates that credit expansion in SSA is more likely to increase financing available to carbon-intensive industries. In a similar study, Yang, et al. (2022) also found that credit expansion is directly linked to upgrading of industrial structures which, in turn, have significant positive impact on carbon emissions. Ntarmah et al. (2021) also found that credit supply had significant positive impact on carbon emissions and economic growth of Central and East African sub-regions which is also in line with findings of this study. Although studies like Rehmam et al. (2023) have demonstrated how credit constraint inhibit carbon emissions in advanced economies, our study has shown that unlike more developed regions where financial credit is often directed toward green projects, SSA's banking sector might still be supporting environmentally harmful industries due to the region's dependence on extractive and energy-intensive sectors. This is because many private sector firms in SSA operate in high-emission industries. The absence of clear environmental regulations on loans in SSA countries may have also strengthened the positive effects of loans on carbon emissions. Unlike in developed economies, where green financing requirements are increasingly imposed, SSA's financial institutions often lack strong environmental lending policies. This means that loans are not necessarily tied to sustainable practices (Yan et al., 2016).

Furthermore, the findings from the study reveal that higher stock market activity in SSA is associated with higher carbon emissions. Both market turnover and value traded demonstrate that stock trading and high turnover do not currently align with sustainability goals. Rather than channeling investments into green industries, the result suggests that SSA countries' capital markets favour high-carbon sectors, such as oil and gas, construction, and mining. Note that it is these sectors (apart from finance) that have higher capitalization in the capital markets of SSA countries. There appears to be a strong distinction between developing and advanced economies in terms of stock market financing of carbon-related firms. For instance, De-Haas and Popov (2019) find that many companies in advanced economies a shifting towards cleaner investment. However, the findings from this study has shown that this is not the case for SSA countries. The positive relationship between stock trading and emissions may also indicate that investors prioritize short-term financial returns over long-term environmental sustainability. Indeed, many SSA stock exchanges are still at the early stages of developing sufficient ESG regulations. This has led to capital being funneled into emission-intensive industries without accountability. Moreover, stock market growth attracts FDI. For SSA countries, a large proportion of FDI flows into polluting sectors due to SSA's reliance on natural resource sector.

The study also found that certified emission reduction (CER) units have failed to impact carbon by SSA countries. This findings suggests that SSA's participation in global carbon credit markets is either ineffective or poorly implemented to the extent that its output has little or no impact on domestic carbon emissions. This can be traced to the weak infrastructure, regulatory enforcement, or market access needed by SSA countries to properly benefit from carbon credit trading (Chen, 2019). In particular, the carbon credit market in SSA countries remains underdeveloped and fragmented. Unlike regions like Asia and Latin America, SSA has few registered carbon development market (CDM) projects due to high transaction costs as well as limited institutional capacity and lack of private sector participation. In the same vein, many CER-funded projects in SSA are small-scale renewable energy or afforestation projects that do not address large-scale industrial emissions in the region.

Finally, the findings from the empirical analysis reveal that climate investment funds (CIF) significantly and negatively influence carbon emissions. The finding is in line with previous studies like Zhout et al. (2023) and Mamun et al. (2023) which were shown in advanced economies. This finding appears to reflect the both the short-term and long-term mitigating capacity of emissions as a result of increased climate infrastructure as well as energy sector investments. Many climate funds are used to develop large-scale projects, such as renewable energy grids, which initially require energy-intensive construction. However, in the long term, these investments could reduce emissions once clean energy sources become operational. Unlike CERs, which rely on market-based trading mechanisms, CIFs provide direct funding for projects that reduce emissions. Similarly, projects financed via CIFs are long-term and scalable which can help to shift SSA economies away from fossil fuel dependency.

In terms of climate funding therefore, the findings from the study indicate that market-based carbon offset mechanisms (CERs) are not effectively reducing emissions, while direct financial interventions through CIF are having a meaningful impact in reducing emissions. Below is an in-depth discussion of these findings and their implications. Notice that CIFs are internationally financed funds designed to support low-carbon development and climate resilience projects in developing countries (Zhout et al., 2023). They provide grants, concessional loans, and technical assistance to help countries transition to sustainable energy, improve climate adaptation, and develop green infrastructure.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Findings

In this study, the relationship among financial development, carbon financing and carbon emission in Sub-Sahara Africa (SSA) was examined. It is argued that carbon financing for addressing sustainability in economic activities can be better driven through a more efficient financial sector in the economy. Hence, the study sets out to evaluate the relative roles of financial development factors like bank credit penetration, financial liquidity, and stock market performance on carbon emission by selected SA countries. Carbon finance was also considered in the study in terms of certified emission reduction (CER) units and climate investment funds. A dynamic framework is devised for the study given that climate issues in relation to economic performance tend to generate several rounds of effects over time. Thus, the pooled mean group which is an autoregressive distributed lags (ARDL) approach to panel data estimation was adopted for the empirical analysis. However, the presence of cross-sectional dependence in the data ensured that the panel correlated standard errors (PCSE) technique was used for robustness tests in the analysis. Data used for the study was annual panel data for seven SSA countries (with developed capital markets) covering the period of 2000 to 2023. The general outcome of the result shows that financial development exact divergent effects on carbon emissions in SSA. Specifically, the following findings were made in the study:

(i) That financial liquidity has a significant negative effect on carbon emission in the Sub-Sahara Africa. This implies that increasing the level of financial sector depth in SSA can help mitigate carbon emissions.

(ii) That banks credits to GDP ratio of SSA countries significant increase carbon emission in the region. There is thus, evidence that banks financing is an important factor the keeps carbon emissions in SSA on the rise.

(iii) That value of stocks traded in the stock market has a significant positive effect on carbon emission in the Sub-Sahara Africa.

(iv) That stock market turnover has a significant positive relationship with carbon emission in the Sub-Sahara Africa. Thus, stock market activities were shown to significantly promote carbon emissions among SSA countries.

(v) That certified emission reduction (CER) unit has no significant effect on carbon emission in the Sub-Sahara Africa.

(vi) That climate investment funds (CIF) has a significant negative effect on carbon emission in the Sub-Sahara Africa. This shows that coordinated financing of climate investments significantly mitigates emissions among SSA countries.

5.2 Conclusion

Reducing carbon emissions in Sub-Saharan Africa (SSA) has become a crucial policy and action paths for achieving sustainable economic growth and environmental stability in the region. While SSA contributes a relatively small share of global greenhouse gas (GHG) emissions, the region is disproportionately vulnerable to climate change. This makes reduction of emissions an urgent priority. In this study, the effects of carbon finance and financial development on carbon emissions in SSA was examined. This study underscores a critical challenge in SSA's financial development by demonstrating that while financial liquidity supports sustainability, private credit allocation still favours high-emission industries. The key to achieving a green transition in SSA therefore lies in directing financial flows toward sustainable sectors while disincentivising carbon-intensive financing. This is more likely to require stronger financial regulations, especially in the banking and stock market sectors of the region. Indeed, the study shows that the banking and stock markets in SSA tend to fuel economic growth while also directly entrenching carbon dependency. Breaking this cycle requires green financial reforms and significant linkage of the domestic financial markets with global systems that can provide leverage for stimulating climate-ready financial systems in SSA countries.

5.3 Recommendations

The findings in this study have provided grounds for making the following recommendations in the study.

(i) The study found that financial liquidity promotes climate efficient economic activities among SSA countries. There is therefore need for SSA countries to enhance financial liquidity through financial sector reforms that promote responsible lending to sustainable businesses. Given that financial depth also includes a larger share of the population being brought within the financial system, governments in SSA countries also need to improve on the level of financial literacy and access to climate-focused funding. This will encourage small and medium businesses to transition more efficiently towards greener operations.

(ii) In the same vein, the capital markets in SSA countries require significant reforms in the area of environmental-implications of market activities. In particular, there is the need for these capital markets to promote green bonds and sustainable investment funds in order to ensure financial liquidity supports low-emission projects. Similarly, the stock exchanges in SSA countries need to be encouraged to adopt green listing requirements for companies. For instance, ESG reporting could be mandated for listed firms.

(iii) The banking sector needs to be reformed in terms of the credit allocation policies with the aim of incentivizing loans for green projects. In this direction, central banks and financial regulators need should create green lending requirements that will ensure that banks prioritize clean energy and sustainable industrial practices. Specifically, banks need to be encouraged to finance more low-interest loans for green investments, such as renewable energy, sustainable manufacturing, and energy-efficient construction.

(iv) In relation to the interactions between emissions challenge and financial market performance, there is the need to strengthen carbon markets in SSA countries by establishing domestic carbon pricing mechanisms and integrating the carbon markets in the economies into global carbon trading platforms. By doing this, the positive benefits of global climate funding systems can be directly linked to the domestic economies through the financial markets.

(v) The study has also found that CER units do not significantly influence carbon emissions in SSA countries. There is therefore need for SSA countries to improve transparency and monitoring of CER projects to ensure real and additional emission reductions. This can be achieved by improving verification mechanisms, ensuring proper pricing of carbon offsets, and increasing SSA countries' participation in international carbon trading schemes.

(vi) Moreover, CIF investments in SSA countries need to be scaled up. This will ensure that more countries benefit from financing for low-carbon transitions. This can be done by aligning CIF projects with national climate goals to maximize their impact on emissions reduction and strengthening partnerships with private investors to attract additional funding for climate-friendly projects.

(vii) Finally, SSA countries also need to ensure that CIF allocations prioritize genuinely green projects. This will help to avoiding the "green washing" phenomenon where funds are allocated to projects that do not result in actual emissions reductions.

5.4 Contributions to Knowledge

This study contributes to the existing body of knowledge in the following ways:

1. This study provided a disaggregated approach to evaluating the implications of the financial system on carbon emission in SSA. Financial prospects were considered from an indirect perspective by focusing on financial liquidity, credit penetration and the stock market, as well as from the direct perspective by focusing on climate financing systems like certified emissions requirements units and climate investment funds. This disaggregation offered a unique perspective on the evaluation of the contribution of finance to environmental sustainability in SSA.
2. Apart from the variable approach to disaggregation in the empirical analysis, this study also contributes to knowledge by including a disaggregation of the SSA panel in terms of individual countries. This variation provided more critical dimensions to the country-specific cases in relation to the finance and climate change nexus in SSA. In particular, the roles of financial sector on climate change and environmental degradation in SSA have been demonstrated in the study to vary in line with the particular country of investigation.
3. Application of a dynamic framework in examining the relationship provides template for identifying both short run and long run implications of finance and carbon emission in SSA from this study.

4. The study provides policy implications for appropriate deployment of domestic financial markets in influencing climate change in SSA. It showed that while the current drive by monetary and fiscal authority if increasing financial inclusion is favourable to the environment in the long run, banks and capital markets need to adjust their current models in order to play more strategic roles in addressing carbon emissions in SSA.

Apart from the variable approach to disaggregation in the empirical analysis, this study also contributes to knowledge by including a disaggregation of the SSA panel in terms of individual countries. This variation provided more critical dimensions to the country-specific cases in relation to the finance and climate change nexus in SSA. In particular, the roles of financial sector on climate change and environmental degradation in SSA have been demonstrated in the study to vary in line with the particular country of investigation

5.5 Area for Further Research

This study examines financial development, carbon financing and carbon emission in SSA using aggregate budget data both financing and carbon emission outcomes. This is a major limitation in the study given that further disaggregation of the data may yield more nuanced outcomes. For instance, sectoral approach to credit allocation may provide clearer insights into whether and how bank credit contributes to carbon emissions. Future research may focus on disaggregating credit data in order to observe detailed relationships. There is however serious challenge of data access in this regard.

REFERENCES

Abbasi, F., & Riaz, K. (2016). CO_2 emissions and financial development in an emerging economy: An augmented VAR approach. *Energy Policy, 90*, 102–114.

Abdullahi, S.I., Tsauni, A.M., & Tabash, M.I. (2022). Gross domestic savings, household consumption, and inequality in Africa: A panel analysis. *Emerging Trends and Insights on Economic Inequality in the Wake of Global Crises,* IGI Global Publishing, 115 – 137.

Abdulraheem, A., Ogbeide, F., Adeboje, O., & Musa, M. (2019). Determinants of financial sector development in Nigeria. *NDIC Quarterly Publication, 34*(12), 1-20.

Abudu, H., Mensah, E., & Danso, S. (2022). The role of bank credits in green investments and carbon emissions reduction. *Journal of Sustainable Finance and Investment, 12*(1), 68-82.

AJLabs (2023). How much does Africa contribute to global carbon emissions? *Interactive Africa CO_2 Emissions, 4,* 169 – 174.

Al-Mulali, U., Chong, W.W., Low, S.T., & Mohammed, A.H. (2015). Investigating the environmental kuznets curve (EKC) hypothesis by utilizing the ecological footprint as an indicator of environmental degradation. *Ecological Indicators*, *48*, 315-323.

Al-Mulali, U., Tang, C.F., & Ozturk, I. (2015). Does financial development reduce environmental degradation? Evidence from a panel study of 129 countries. *Environmental Science and Pollution Research, 22*(19), 14891-14900.

Alomet, K., Uddin, A.N.M., & Islam, N. (2017). Energy consumption, $C0_2$ emissions, urbanization and financial development in Bangladesh: Vector error correction model. *Journal of Global Economics, Management and Business Research, 9*(4), 178-189.

Altay, B., & Topcu, M. (2017). Re-examining the impact of financial system on economic growth: New evidence from heterogeneous regional panel. *Handbook of Research on Global Enterprise Operations and Opportunities*, 16, 1-15.

Aluko, O.A., & Obalade, A.A. (2020). Financial development and environmental quality in sub Saharan Africa: Is there a technology effect? *Science Total Environment*, *10*, 747-762.

Amuakwa - Mensah, F., & Adom. P.K (2017). Quality of institution and the FEG (forest, energy intensity, and globalization) environment relationships in Sub-Saharan Africa. *Environmental Science and Pollution Research*, *24*(9), 17455 – 17473.

Asghari, M. (2013). Does economic and financial development matter for environmental degradation? *Middle-East Journal of Scientific Research, 14*(2), 221-227.

Aydogan, S. (2021). Greenhouse gas emissions and carbon footprints: A global perspective. *Environmental Science and Pollution Research*, 28(12), 13479-13489.

Aydogan, Y. (2021). Transformation of the Turkish automotive sector: The electric vehicle challenge. *Electric Vehicles and the Future of Energy Efficient Transportation, 21*(6), 16-21.

Aye, G.C., & Edoja, P.E. (2017). Effect of economic growth on CO_2 emissions in developing countries: Evidence from a dynamic panel threshold model. *Cogent Economics and Finance, 5*(1), 1 -22.

Bahtiyar, G. (2015). Globalization, financial development and income inequality. *Handbook of Research on Strategic Developments and Regulatory Practice in Global Finance, 26*(4), 66-81.

Bayar, Y., Maxim, L.D., & Maxim, A. (2020). Financial development and CO_2 emissions in post-transition European Union Countries. *Sustainability,12*(7), 2640-2656.

Bekhet, H.A., Matar, A., & Yasmin, T. (2017). CO_2 emissions, energy consumption, economic growth, and financial development in GCC countries: Dynamic simultaneous equation models. *Renew Sustainable Energy Review, 70*, 117–132.

Bimanatya, T.E., & Widodo, T. (2018). Fossil fuels consumption, carbon emissions and economic growth in Indonesia. *International Journal of Energy Economics and Policy*, *8*(4), 90 – 97.

Brundtland, G.H. (1987). *Address at the closing ceremony of the final meeting of the World Commission on Environment and Development.* Tokyo, Japan, 1-16.

Bui, B., Moses, O., & Houqe, M.N. (2020). Carbon disclosure, emission intensity and cost of equity capital: Multi-country evidence. *Accounting and Finance*, *60*, 47–71.

Bui, D.T. (2020). Transmission channels between financial development and CO_2 emissions: A global perspective. *Heliyon, 6,* 1-9.

Cagatay, B., David, H.,& Prati, A. (2012). The interest group theory of financial development: Evidence from regulation. European bank for reconstruction and development working paper no. 150, London.

Campos, N.F., & Kinoshita, Y. (2003). Why does FDI go where it goes? New evidence from the transition economies. *International Monetary Fund Working Paper*, 228-243.

Certified Emission Reduction Units (2020). *Australian national registry of emissions units act Assessed on 11/01/2024 from* https://www.cleanenergyregulator.gov.au/OSR/ANREU/types-of-emissions-units/certified-emission-reduction-units

Çetin, M., Ecevit, E., Seker, F., & Günaydin, D. (2015). Financial development and energy consumption in Turkey: Empirical evidence from cointegration and causality tests. *Handbook of Research on Behavioral Finance and Investment Strategies: Decision Making in the Financial Industry,* 297-314.

Chen, Q. (2019). Has China's green credit police been implemented? An analysis of loan scale and costs based on "two highs and one surplus" enterprises. *Contemporary Finance Economic, 40*(03), 118–129.

Chen, Z., Zhang, X., & Chen, F. (2021). Do carbon emission trading schemes stimulate green innovation in enterprises? Evidence from China. *Technological Forecasting and Social Change*, *168 (2)*, 120- 142.

Chia-Lin, C., Jukka, I., Hannu, L., & Michael, M. (2020). Causality between CO_2 emissions and stock markets. *Energies, 13*(11), 1-15.

Chireshe, J. (2021). Finance and renewable energy development nexus: Evidence from Sub Saharan Africa. *International Journal of Energy Economics and Policy, 11*(1), 318-325.

Chovancova, J., Petruska, I., Rovnak, M. & Barlak, J. (2024). Investigating the drivers of CO2 emissions in the EU: Advanced estimation with common correlated effects and common factors models. *Energy Reports*, 11, 937-950.

Chummun, B.Z. (2023). Can green products and services in the insurance industry be a sustainable measure? *Handbook of Research on Sustainable Consumption and Production for Greener Economies*, 91-106.

Chummun, M. (2023). Carbon emissions and their implications on air quality. *Environmental Impact Journal*, *11*(4), 223-236.

Claessens, S., & Feijen, E. (2007). Financial sector development and the millennium development goals. *World Bank Working Paper No. 89*, 1-18.

Climate Action Tracker (2023). *Nigeria's overall rating almost sufficient*. Retrieved on 28/07/2023 from https://climateactiontracker.org/countries/nigeria.

Climate Investment Funds (2010). *Design document for the forest investment program: A targeted program under the SCF Trust Fund.* Accessed January 11, 2024 from http://www.climateinvestmentfunds.org/cif/.

Climate Investment Funds (2020a). History of the CIF. Assessed on 11/01/2024, from https://www.climateinvestmentfunds.org/timeline-cif

Climate Investment Funds (2023). Exploring the gender dimensions of carbon finance mechanisms. *UNDP Global Gender and Climate Alliance*, 1-4.

Dasgupta, S., Laplante, B., Wang, H., & Wheeler, D. (2002). Confronting the environmental kuznets curve. *Journal of Economic Perspectives, 16*(1), 147-168.

De-Haas, R., & Popov, A. (2019). Finance and carbon emissions. *European Central Bank Working Paper Series*, 1-70.

Ding, J. (2019). Green credit policy, credit resources allocation and strategic response of enterprises. *Economic Review, 40*(04), 62–75.

Ding, X., Ren, Y., Tan, W., & Wu, H. (2023). Does Carbon emission of firms matter for bank loans decision? Evidence from china. *International Review of Financial Analysis, 86*(5), 1-15.

Emenekwe, C.C., Onyeneke, R., & Nwajiuba, C.U. (2022). Financial development and carbon emissions in Sub-Saharan Africa. *Environmental Science and Pollution Research International, 29*(6), 123-138.

Eryigit, K.Y., & Eryigit, S.B. (2015). Foreign direct investment, financial development and economic growth: The case of Turkey. *Handbook of Research on Strategic Developments and Regulatory Practice in Global Finance, 18(4)*, 16-38.

Eryigit, S.B., & Dulgeroglu, E. (2015). How to measure the level of financial development. *Handbook of Research on Strategic Developments and Regulatory Practice in Global Finance, 27(2), 25-45*.

Eryılmaz, F., Bakır, H., & Mercan, M. (2015). Financial development and economic growth: Panel data analysis. *Handbook of Research on Strategic Developments and Regulatory Practice in Global Finance,* 13-385.

Eurostat Statistic Explained (2023). Glossary: Carbon dioxide emissions. Retrieved on 30/07/2023fromhttps://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Glossar: Carbon_dioxide_emissions.

Fabra, N., & Reguant, M. (2014). Pass-through of emissions costs in electricity markets. *An Economic Review, 10(4)*, 2872–2899.

Fleming, J.R. (1998). *Historical perspectives on climate change*. New York and Oxford: Oxford University Press.

Ghoshi, S. (2010). Credit growth, bank's soundness and financial fragility: Evidence from the Indian banking sector. *South Asian Economic Journal*, *11*(1), 69 -98.

Gillenwater, M., & Seres, S. (2011). The clean development mechanism: A review of the first international offset programme. *Greenhouse Gas Measurement and Management, 1(*3), 179-203.

Global Environment Outlook 4 (2007). Environment for development. *UNEP, Malta. 1-10*

Goldsmith, R. (1969). *Financial structure and development*, New Haven: Yale University Press,

Goodland, R., & Anhang, J. (2009). *Livestock and climate change: what if the key actors in climate change are cows, pigs and chickens*? World Watch, www.worldwatch.org

Gui F. Ren, S., Zhao, Y., Zhou, J., Xie, Z., Xu, C., & Zhu, F. (2019). Activity-based allocation and optimization for carbon footprint and cost in product lifecycle. *Journal of Clean Production, 236*, 117627-117640.

Guiso, L., Sapienza P., & Zingales, L. (2006). The cost of banking regulation. *NBER working paper No. 12501. National Bureau of Economic Research,* Cambridge, MA.

Guo, C., Wang, X., Cao, D., & Hou, Y. (2022). The impact of green finance on carbon emission: Analysis based on mediation effect and spatial effect. *School of Economics and Management, 10(3), 21-43.*

Habiba, U., & Xinbang, C. (2022). An investigation of the dynamic relationships between financial development, renewable energy use, and CO_2 emissions. *SAGE Journal,* 9(2), 1–21.

Hansen, L. P. (1982). Large sample properties of generalized method of moments estimators. *Econometrica: Journal of the Econometric Society*, 1029-1054.

Heinrich Böll Foundation South Africa (2011). *Perspectives. Special issue on carbon finance for Africa climate funds update*: Assessed from http://www.climatefundsupdate.org/

Henry, P.B. (2007). Capital account liberalization: Theory, evidence, and speculation. *Journal of Economic Literature, 45*, 887–935.

Heubaum, H., & Volz, U. (2022). *Carbon finance: Background note,* SOAS University of London, 1-7.

Hsiao, C. (1986). *Analysis of panel data.* Cambridge: Cambridge University press.

International Energy Agency. (2019). *World energy outlook. Assessed from* https://www.iea.org/reports/world energy-outlook-2019.

IPCC (2018). Global warming of 1.5°C. *An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways,* 1-18.

Iskandar, A. (2019). Economic growth and CO_2 emissions in Indonesia: Investigating the environmental Kuznets curve hypothesis existence. *Journal of BPPK*, *12*, 42–52.

Jiang, H.L., Wang, W.D., Wang, L., & Wu, J.H. (2020). The effects of the carbon emission reduction of China's Green Finance: An analysis based on green credit and green venture investment. *Finance Forum, 25*(11), 39–48.

Khan, M.K., Khan, M.I., & Rehan, M. (2020). The relationship between energy consumption, economic and carbon dioxide emissions in Pakistan. *Financial Innovation Journal, 6*(1), 1-21.

Khudari, M., Darweesh, F., & Othman, N.S. (2024). The impact financial development on carbon emissions: A systematic review of the literature. *Journal of Research Administration, 6*(1), 1516-1545.

Kilavuz, E., & Dogan, I. (2021). Economic growth, Openness, Industry and CO_2 modeling: are regulatory policies important in Turkish economies? *International Journal of Low – Carbon Technologies, 16*(2), 476 -487.

Kilinc-Ata, N. (2022). The asymmetric impact of economic growth, energy consumption, population, and R&D on carbon emission in Turkey: Evidence from ARDL and non-linear ARDL. *Handbook of Research on Sustainable Development Goals, Climate Change, and Digitalization,* 16(1), 19-37.

Kim, J., & Park, K. (2015). Financial development and deployment of renewable energy technologies. *Energy Economics, 59*, 238-250.

Koçak, E., & Şarkgüneşi, A. (2018). The impact of foreign direct investment on CO2 emissions in Turkey: new evidence from cointegration and bootstrap causality analysis. *Environmental Science Pollution Research, 25*(1), 790–804.

Kong, Y., & Wei, F. (2017). Financial development, financial structure and carbon emission. *Environmental Engineering and Management Journal, 16*(7), 1609-1622.

Lanoie, P., Laplante, B., & Roy, M. (1998). Can capital markets create incentives for pollution control? *Ecological Economics*, *26*(1), 31-41.

Lawinsider (2023). *Carbon emission definitions.* Retrieved on 30/07/2023 from https://www.lawinsider.com/dictionary/carbon-emissions.

Li, L., Liu, D., Hou, J., Xu, D., & Chao, W. (2019). The study of the impact of carbon finance effect on carbon emissions in Beijing-Tianjin-Hebei region, based on logarithmic mean divisia index decomposition analysis. *Sustainability*, *11*(5), 1465-1483.

Liang, C., Wei, Y., Li, X., Zhang, X., & Zhang, Y. (2020). Uncertainty and crude oil market volatility: New evidence. *Applied Economics, 52*(27), 2945–2959.

Lin, D.J., Chen, J.L., & Qiu, G.Y. (2018). Research on green financial support factors of China's environmental protection industry: An empirical analysis based on the constituent stocks of the CSI environmental protection industry 50 Index. *Journal of Industry Technology Economic, 37(*5), 129–135.

Liu, M., Zhou, C., Lu, F., & Hu, X. (2021). Impact of the implementation of carbon emission trading on corporate financial performance: Evidence from listed companies in China. *16*(2), 0253460-0253475.

Mamun, M. A., Boubaker, S., & Nguyen, D. K. (2023). *Green finance, renewable energy and carbon neutrality in OECD countries*. *Renewable Energy, 211*, 279–284.

Marcelo, J. (2005). Carbon credits from cogeneration with bagasse. *Bioenergy - Realizing the Potential,* 1-10.

McKinnon, R. I. (1973). *Money and capital in economic development. The American Political Science Review, 68(4), 1822-1844.*

Miao, X., & Li, N. (2023). *How carbon emission affects stock returns and business management in China*. University of Waterloo, Waterloo, Canada; 794-802.

Nasreen, S., Anwar, S., & Ozturk, I. (2017). Financial stability, energy consumption and environmental quality: Evidence from South Asian economies. *Renewable and Sustainable Energy Reviews, 67*, 1105-1122.

Niu, H.P., Zhang, X.Y., & Zhang, P.D. (2020). Institutional change and effect evaluation of green finance policy in China: Evidence from green credit policy. *Management Review, 32*(8), 3–12.

Ntarmah, A.H., Kong, Y., & Manu, E.K. (2021). Investigating the dynamic relationships between credit supply, economic growth, and the environment: empirical evidence of sub-regional economies in Sub-Saharan Africa. *Environmental Science and Pollution Research International, 28*(5), 5786-5808.

Nuru, N.Y., & Gereziher, H.Y. (2021). The growth effects of financial development over economic cycle in South Africa. *Handbook of Research on Institution Development for Sustainable and Inclusive Economic Growth in Africa*, 17(3), 29-51.

Nwabueze, E. E., Abner, I.P., Victor, E. I., Nwude, C.E., Samuel, O.J., & Udo, S.E. (2023). Financial development, foreign direct investment, and CO_2 emissions nexus: Evidence from Sub-Saharan Africa**.** *Journal of Hunan University Natural Sciences, 50*(6), 121-135.

Obayagbona, J., (2023). Carbon footprint and economic growth in Nigeria and Ghana. *Research papers in Economics and Finance. 7(2),* 18-43.

Obayagbona, J., & Osayande, O. (2020). Market liquidity of Sub-Saharan African capital markets. *Proceedings of the 1st International Conference of Faculty of Management Sciences, University of Benin. Theme:* Accountability, Governance, Sustainability and Value Creation, January 15-17, 480-490.

Odhiambo, N.M. (2020). Financial development income inequality and carbon emissions in Sub-Saharan African Countries: A panel data analysis. *Energy Exploration & Exploitation*, *38*(5), 1914 – 1931.

Oestreich, A.M., & Tsiakas, I. (2015). Carbon emissions and stock returns: Evidence from the EU emissions trading scheme. *Journal of Banking and Finance*, *58*, 294–308.

Ojewumi, S.J., & Akinlo, A.E. (2017). Foreign direct investment, economic growth and environmental quality in sub-Saharan Africa: a dynamic model analysis. *African Journal of Economic Review (AJER), 5*(1), 48–68.

Olubusoye, O.E., & Dasauki, M.C. (2018). Carbon emissions, energy consumption and economic growth in Africa. Munich Personal RePEc Archive (MPRA), 96-159.

Olubusoye, O.E., & Dasauki, M.C. (2020). Carbon emissions and economic growth in Africa: Are they related? *Cogent Economics & Finance, 8*, 1 – 21.

Onanuga, O.T. (2017). The impact of economic and financial development on carbon emissions: evidence from Sub-Saharan Africa. Thesis submitted in accordance with the requirements for the Degree of Doctor of Philosophy in Economics at the University of South Africa, 1- 272.

Onwioduowit, E.,& O'Neil, H. (2024). Bank's credit dynamics and its influence on output growth in the Nigerian economy. *MPRA Paper No. 119552, Munich Personal RePEc Archive*. Retrieved from https://mpra.uni-muenchen.de/119552

Parry, I. (2021). Five things to know about carbon pricing. *International Monetary Fund,* 1-6.

Pesaran, M. H. (2004). General diagnostic tests for cross sectional dependence in panels. Cambridge Working Papers in Economics, No. 0435, University of Cambridge, England.

Pesaran, M. H, Shin, Y., & Smith, R.J (2001). Bound testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, *16*(3), 289-326.

Pesaran, M.H., Shin, Y., & Smith, R.J. (2003). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16, 289–326

Plass, G. N. (1956). The carbon dioxide theory of climatic change. *Tellus*, *8*(2), 140–154.

Rahman, M.M., & Alam, K. (2022). CO_2 emissions in Asia–pacific region: Do energy use, economic growth, financial development, and international trade have detrimental effects? *Sustainability, 14*, 10-20.

Rajan, R.G., & Ramcharan, (2008). Landed interests and financial underdevelopment in the United States, Working paper no. 14347, National Bureau of Economic Research, Cambridge.

Rajan, R.G., & Zingales, L. (2003). The great reversals: The politics of financial development in the twentieth century. *Journal of Financial Economics, 69*, 5–50.

Ralph, D., & Alexander, P. (2019). A finance and carbon emissions. *ECB Working Paper No. 2318*, 1-16.

Rees, W.E. (1992). Ecological footprints and appropriated carrying capacity: what urban economics leaves out. *Environment and Urbanization*, *4*(2), 121–130.

Rehman, I.U., Shahzad, F., Hanif, M.A., Arshad, A., & Sergi, B.S. (2023). Financial constraints and carbon emissions: an empirical investigation. *Social Responsibility Journal* 20(4), 1-16.

Rizvi, S.K.A., Mirza, B.N.N., & Porada-Rochon, R.I. (2021).Is there a green fund premium? Evidence from twenty seven emerging markets. *Global Finance Journal,* 50, 100656-1006670.

Sabbaghi, O., Li, .J., & Sabbaghi, N. (2018). Certified emissions reduction credits and the role of investments: Evidence from Wind CDM projects in China. *International Journal of Energy Sector Management*, *12* (3). 386 - 407.

Sadorsky, P. (2011). The impact of financial development on energy consumption in emerging economies. *Energy Policy, 38*, 2528-2535.

Salahuddin, M., Gow, J., & Ozturk, I. (2015). Is the long-run relationship between economic growth, electricity consumption and carbon dioxide emissions and financial development in Gulf Cooperation Council countries robust? *Renewable and Sustainable Energy Reviews*, *51*, 317-326.

Sarkodie, S.A., & Strezov, V. (2019). Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. *Science Total Environment, 646*, 862–871.

Sasu, D.D. (2023). CO_2 emissions in Africa 2021, by country. *Energy & Environment›Emissions.* Retrieved on 04/10/2023 from https://www.statista.com/statistics/1268395/production-based-co2-emissions-in-africa-by-country/

Schumpeter, J.A. (1973). *Business cycles: A theoretical historical and statistical analysis of the capitalist process,* New York: McGraw-Hill.

Shahbaz, M., Solarin, S.A., & Mahmood, H. (2012b). Does financial development reduce CO_2 emissions in Malaysian economy? A time series analysis. *Munich Personal Repec Archive (MPRA), Paper No.* 40603, 1-17.

Shaw, E. S. (1973). *Financial deepening in economic development,* New York. Oxford University press.

Shen, Y., Su, Z.W., Malik, M.Y., Umar, M., Khan, Z., & Khan, M. (2021). Does green investment, financial development and natural resources rent limit carbon emissions? A provincial panel analysis of China. Science of *Total Environment,* 8(2), 755-782.

Ssali, M.W., Du, J., Mensah, I.A., & Hongo, D.O.(2019). Investigating the nexus among environmental pollution, economic growth, energy use, and foreign direct investment in 6 selected sub-Saharan African countries. *Environmental Science and Pollution Research International, 29*(11), 11245-11260.

Stein, Z. (2023). Climate investment fund. Retrieved on 11/01/2024 from https://www.carboncollective.co/sustainable-investing/climate-investment-fund**.**

Stocker, T. F., Qin, D., Plattner, G. K., Tignor, M. M., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., Bex, V., & Midgley, P. M. (2014). *Climate change 2013: The physical science basis. Contribution of working group I to the fifth assessment report of IPCC the intergovernmental panel on climate change.* Cambridge University press.

Su, C., Li, W., Umar, M., & Lobonţ, O. (2022). Can green credit reduce the emissions of pollutants? *Economic Analysis and Policy, 74*, 205 219.

Syafrudin, S., Zaman, B., Budihardjo, M.A., Yumaroh, S., Gita, D.I., & Lantip, D.S. (2020). Carbon footprint of academic activities: A case study in Diponegoro University. *IOP Conf. Series: Earth and Environmental Science, 448,1-6.*

Tamazian, A., & Rao, B.B. (2010). Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economics. *Energy Economics*, *32*(1), 137-145.

Tamazian, A., Piñeiro, J.C., & Vadlamannati, K.C. (2009). Does higher economic and financial development lead to environmental degradation: Evidence from BRIC countries? *Energy Policy, 37*, 246–253.

Tang, M., Cheng, S., Guo, W., Ma, W., & Hu, F. (2022). Effects of carbon emission trading on companies' market value: Evidence from listed companies in China. *Atmosphere, 13*, 1-25.

Tang, M., Li, Z., Hu, F., Wu, B., & Zhang, R. (2021). Market failure, tradable discharge permit, and pollution reduction: Evidence from industrial firms in China. *Ecological Economics*, *189*, 107-180.

Tressel, T., & Detragiache, E. (2008). Do financial sector reforms lead to financial development? Evidence from a new dataset. *IMF Working Paper WP/08/265*.Washington: International Monetary Fund.

Tsaurai, K. (2019). The impact of financial development on carbon emissions in Africa. *International Journal of Energy Economics and Policy, 9*(3), 144-153.

Tyndall, J. (1861). On the absorption and radiation of heat by gases and vapours, and on the physical connection of radiation, absorption, and conduction. *Philosophical Magazine, 4*(22), 169–194.

Umar, M., & Safi, A. (2023). Do green finance and innovation matter for environmental protection? A case of OECD economies. *Energy Economics, 119*, 1-11.

Umar, M., Ji, X., Mirza, N., & Naqvi, B. (2021). Carbon neutrality, bank lending, and credit risk: Evidence from the Eurozone. *Journal of Environmental Management, 296*, 113-156.

UN Environment Programme (2019). *Six African countries switch to green business development for sustainable growth, 1-5*.

UNHCR (2021). *Global strategy for safe access to fuel and energy (SAFE) 2014-2018*. Retrieved from http://www.unhcr.org/530f11ee6.html.

Unhelkar, B., & Lan, Y. (2011). Integrating green ICT in a supply chain management system. *Handbook of Research on Green ICT: Technology, Business and Social Perspectives, 12*(1), 934-945.

Veith, S., Werner, J.R., & Zimmermann, J. (2009). Capital market response to emission rights returns: Evidence from the European power sector. *Energy Economics, 31*, 605–613.

Wang, L., Vo, X.V., Shahbaz, M., & Ak, A. (2020). Globalization and carbon emissions: Is there any role of agriculture value-added, financial development, and natural resource rent in the aftermath of COP21? *Journal of Environment and Management, 13*(4), 268-280.

Windmieger, F. (2006). GMM for panel count data models. *Department of Economics, University of Bristol, Discussion Paper No. 06/591*; 1-18.

World Bank (1999). Economic growth and environmental quality: Time series and cross – country evidence. *World Bank Working Papers Series*, 904.

Wu, S.S. (2018). How does bank credit affect carbon emissions? Research based on growth model and Chinese experience. *Journal of Zhongnan University Economic Literature, 61*(6), 22–43.

Xie, T.T., & Liu, J.H. (2019). How does green credit affect China's green economy growth? Chin. *Journal of Population Resource Environment, 29*(9), 83–90.

Xuezhou, W., Manu, E.K., & Akowuah· I.N. (2022). Financial development and environmental quality: the role of economic growth among the regional economies of Sub-Saharan Africa. *Environmental Science and Pollution Research International, 29*(16), 23069-23093.

Yan, C.L., Li, T., & Lan, W. (2016). Financial development, innovation and carbon emission. *Journal of Financial Resources, 39*(1), 14–30.

Yang, W., Tan, M., Chu, S., & Chen, Z. (2022). Carbon emission and financial development under the "double carbon" goal: Considering the upgrade of industrial structure. *Frontiers in Environmental Science*, *10*, 1-11.

Yuan, R., Liao, H., & Juan Wang, J. (2022). A nexus study of carbon emissions and financial development in China using the decoupling analysis. *Environmental Science and Pollution Research, 29, 1-16.*

Zhao, W. (2021). Financial globalization and the development of China's economy. *Handbook of Research on Institutional, Economic, and Social Impacts of Globalization and Liberalization*, 19(2), 679-699.

Zhou, Y., Zhou, Z., Zhang, Y., & Chang, Y. (2023). Effect of green finance on industrial carbon emissions in China: Empirical analysis based on provincial panel data. *China Economic Research,* 35(6), 6965-6984.

APPENDICES

Appendix I

List of 49 SSA countries

No.	Country
1	Angola
2	Benin
3	Botswana
4	Burkina Faso
5	Burundi
6	Cabo Verde
7	Cameroon
8	Central African Republic
9	Chad
10	Comoros
11	Congo (Republic of)
12	Congo (Democratic Republic of)
13	Côte d'Ivoire
14	Djibouti
15	Equatorial Guinea
16	Eritrea
17	Eswatini
18	Ethiopia
19	Gabon
20	Gambia
21	Ghana
22	Guinea
23	Guinea-Bissau
24	Kenya
25	Lesotho
26	Liberia
27	Madagascar
28	Malawi
29	Mali
30	Mauritania
31	Mauritius
32	Mozambique
33	Namibia
34	Niger
35	Nigeria
36	Rwanda
37	São Tomé and Príncipe
38	Senegal
39	Seychelles

40	Sierra Leone
41	Somalia
42	South Africa
43	South Sudan
44	Sudan
45	Tanzania
46	Togo
47	Uganda
48	Zambia
49	Zimbabwe

Source: The UN Development Programme (2023). United Nations geographical regions

Appendix II

Data for Analysis

Country	YEAR	GHGPC	GHG	FINL	BC_GDP	FINL
Côte d'Ivoire	2000	0.93	16.47	13.98	9.76	13.98
Côte d'Ivoire	2001	0.92	16.68	24.82	14.69	24.82
Côte d'Ivoire	2002	0.94	17.45	26.11	16.74	26.11
Côte d'Ivoire	2003	0.84	16.00	27.37	17.67	27.37
Côte d'Ivoire	2004	0.86	16.80	28.12	19.25	28.12
Côte d'Ivoire	2005	0.88	17.74	29.91	19.27	29.91
Côte d'Ivoire	2006	0.87	17.90	30.44	19.05	30.44
Côte d'Ivoire	2007	0.86	18.03	35.95	20.57	35.95
Côte d'Ivoire	2008	0.87	18.74	38.37	21.00	38.37
Côte d'Ivoire	2009	0.83	18.18	38.56	21.08	38.56
Côte d'Ivoire	2010	0.87	19.54	36.45	22.43	36.45
Côte d'Ivoire	2011	0.88	20.18	18.85	12.16	18.85
Côte d'Ivoire	2012	0.97	22.78	14.86	10.15	14.86
Côte d'Ivoire	2013	1.01	24.09	13.69	8.85	13.69
Côte d'Ivoire	2014	1.02	25.03	14.02	9.48	14.02
Côte d'Ivoire	2015	1.03	26.10	13.11	9.03	13.11
Côte d'Ivoire	2016	1.05	27.20	17.84	9.64	17.84
Côte d'Ivoire	2017	1.05	28.10	24.82	14.32	24.82
Côte d'Ivoire	2018	1.00	27.54	25.40	13.68	25.40
Côte d'Ivoire	2019	1.04	29.42	25.97	13.17	25.97
Côte d'Ivoire	2020	1.02	29.50	23.40	13.09	23.40
Côte d'Ivoire	2021	1.06	31.53	21.31	12.70	21.31
Côte d'Ivoire	2022	1.06	32.17	18.44	12.03	18.44
Côte d'Ivoire	2023	1.03	32.18	13.98	9.44	13.98
Ghana	2000	0.78	15.27	28.17	13.97	28.17
Ghana	2001	0.79	15.89	23.64	16.50	23.64
Ghana	2002	0.83	17.24	25.67	17.93	25.67
Ghana	2003	0.79	16.91	26.28	17.44	26.28
Ghana	2004	0.77	16.82	25.49	16.10	25.49
Ghana	2005	0.78	17.45	25.13	13.71	25.13
Ghana	2006	0.84	19.41	26.39	13.94	26.39
Ghana	2007	0.84	19.94	30.82	13.06	30.82
Ghana	2008	0.89	21.53	31.73	13.05	31.73
Ghana	2009	0.91	22.60	31.49	13.29	31.49
Ghana	2010	0.94	23.85	31.58	9.96	31.58
Ghana	2011	1.03	26.97	25.72	14.49	25.72
Ghana	2012	1.11	29.81	22.77	10.86	22.77
Ghana	2013	1.16	31.90	32.11	15.54	32.11
Ghana	2014	1.14	32.07	32.72	13.17	32.72
Ghana	2015	1.16	33.31	31.05	12.49	31.05
Ghana	2016	1.15	33.85	34.11	12.15	34.11
Ghana	2017	1.23	37.03	21.95	15.29	21.95
Ghana	2018	1.29	39.66	30.36	18.07	30.36
Ghana	2019	1.37	42.71	30.55	17.20	30.55
Ghana	2020	1.42	45.35	29.62	16.66	29.62
Ghana	2021	1.45	46.99	28.25	17.74	28.25

Ghana	2022	1.45	48.20	27.46	12.61	27.46
Ghana	2023	1.43	48.27	31.45	11.88	31.45
Kenya	2000	1.35	41.28	35.16	25.76	35.16
Kenya	2001	1.34	42.24	42.30	34.52	42.30
Kenya	2002	1.37	44.61	42.82	36.70	42.82
Kenya	2003	1.36	45.92	40.33	35.57	40.33
Kenya	2004	1.45	50.26	39.35	33.15	39.35
Kenya	2005	1.47	52.72	39.36	31.20	39.36
Kenya	2006	1.40	51.49	38.07	30.83	38.07
Kenya	2007	1.87	71.27	41.20	32.15	41.20
Kenya	2008	1.94	76.00	38.99	31.12	38.99
Kenya	2009	1.85	74.93	37.38	31.26	37.38
Kenya	2010	1.89	78.51	40.01	31.64	40.01
Kenya	2011	1.86	79.35	36.06	23.04	36.06
Kenya	2012	1.77	77.72	34.60	22.89	34.60
Kenya	2013	1.73	78.04	38.91	26.28	38.91
Kenya	2014	1.75	80.41	39.33	27.29	39.33
Kenya	2015	1.76	82.65	39.02	25.16	39.02
Kenya	2016	1.85	88.96	38.16	25.85	38.16
Kenya	2017	1.75	86.06	37.79	28.33	37.79
Kenya	2018	1.76	88.31	36.53	26.40	36.53
Kenya	2019	1.89	97.01	36.57	27.37	36.57
Kenya	2020	2.08	108.42	35.51	23.99	35.51
Kenya	2021	1.91	101.81	31.87	21.87	31.87
Kenya	2022	1.92	104.29	36.11	25.38	36.11
Kenya	2023	1.95	107.98	35.24	25.22	35.24
Mauritius	2000	2.73	3.24	77.01	55.75	77.01
Mauritius	2001	2.84	3.39	99.30	96.73	99.30
Mauritius	2002	2.81	3.39	104.05	100.02	104.05
Mauritius	2003	2.86	3.47	106.74	93.50	106.74
Mauritius	2004	2.88	3.52	110.41	98.98	110.41
Mauritius	2005	3.00	3.68	110.97	75.31	110.97
Mauritius	2006	3.59	4.44	117.55	78.08	117.55
Mauritius	2007	3.69	4.57	156.75	91.81	156.75
Mauritius	2008	3.77	4.69	159.95	86.44	159.95
Mauritius	2009	3.76	4.69	141.13	72.42	141.13
Mauritius	2010	3.98	4.98	130.43	67.16	130.43
Mauritius	2011	4.00	5.01	93.77	71.75	93.77
Mauritius	2012	4.08	5.12	93.11	68.69	93.11
Mauritius	2013	4.19	5.28	97.66	71.93	97.66
Mauritius	2014	4.35	5.48	96.96	69.97	96.96
Mauritius	2015	4.38	5.53	90.93	69.71	90.93
Mauritius	2016	4.47	5.64	81.36	56.93	81.36
Mauritius	2017	4.65	5.88	96.87	104.89	96.87
Mauritius	2018	4.66	5.89	98.57	98.85	98.57
Mauritius	2019	4.72	5.97	96.64	89.31	96.64
Mauritius	2020	4.40	5.57	97.49	85.36	97.49
Mauritius	2021	4.63	5.86	96.25	80.08	96.25
Mauritius	2022	4.73	5.97	96.50	81.80	96.50
Mauritius	2023	4.92	6.20	77.96	56.10	77.96

Namibia	2000	4.59	8.34	39.84	65.22	39.84
Namibia	2001	4.76	8.84	55.15	65.40	55.15
Namibia	2002	4.41	8.34	55.57	65.63	55.57
Namibia	2003	4.48	8.59	54.56	68.57	54.56
Namibia	2004	4.49	8.72	57.16	65.09	57.16
Namibia	2005	5.35	10.52	57.63	65.84	57.63
Namibia	2006	4.55	9.05	63.65	70.95	63.65
Namibia	2007	4.50	9.08	71.54	72.77	71.54
Namibia	2008	4.87	9.98	72.61	68.85	72.61
Namibia	2009	4.78	9.93	51.93	61.03	51.93
Namibia	2010	4.71	9.94	47.46	62.64	47.46
Namibia	2011	4.70	10.08	42.18	64.96	42.18
Namibia	2012	5.18	11.36	41.83	66.95	41.83
Namibia	2013	4.85	10.93	37.78	65.56	37.78
Namibia	2014	5.04	11.65	38.92	64.35	38.92
Namibia	2015	4.96	11.78	36.39	64.18	36.39
Namibia	2016	5.21	12.71	37.63	64.93	37.63
Namibia	2017	4.89	12.26	58.73	67.46	58.73
Namibia	2018	4.69	12.08	57.21	67.94	57.21
Namibia	2019	4.61	12.21	64.22	69.35	64.22
Namibia	2020	4.12	11.26	62.73	70.07	62.73
Namibia	2021	4.32	12.14	62.43	72.94	62.43
Namibia	2022	4.42	12.78	41.96	71.70	41.96
Namibia	2023	4.35	12.89	37.60	71.29	37.60
Nigeria	2000	3.21	405.32	14.67	8.25	14.67
Nigeria	2001	3.18	412.90	22.69	13.30	22.69
Nigeria	2002	2.70	360.97	22.37	13.08	22.37
Nigeria	2003	2.90	397.69	27.38	14.61	27.38
Nigeria	2004	2.76	389.60	24.78	12.85	24.78
Nigeria	2005	2.64	382.54	25.36	10.25	25.36
Nigeria	2006	2.39	356.28	23.93	11.16	23.93
Nigeria	2007	2.18	334.22	25.22	12.13	25.22
Nigeria	2008	2.15	338.64	25.24	13.45	25.24
Nigeria	2009	1.98	321.58	25.79	12.96	25.79
Nigeria	2010	2.08	345.85	22.37	13.41	22.37
Nigeria	2011	2.15	368.08	19.29	13.80	19.29
Nigeria	2012	2.11	372.38	11.73	8.12	11.73
Nigeria	2013	2.09	377.91	11.30	8.44	11.30
Nigeria	2014	2.09	388.37	11.76	8.46	11.76
Nigeria	2015	2.00	382.05	13.03	8.91	13.03
Nigeria	2016	1.93	377.92	13.53	8.08	13.53
Nigeria	2017	1.91	383.46	25.45	11.53	25.45
Nigeria	2018	1.92	394.33	24.93	10.60	24.93
Nigeria	2019	1.95	408.14	22.48	11.04	22.48
Nigeria	2020	1.78	381.24	21.36	13.49	21.36
Nigeria	2021	1.77	386.80	25.14	19.63	25.14
Nigeria	2022	1.70	380.16	23.81	18.63	23.81
Nigeria	2023	1.69	385.11	15.90	9.88	15.90
South Africa	2000	9.57	451.25	47.36	117.10	47.36
South Africa	2001	9.72	462.24	65.24	128.84	65.24

South Africa	2002	9.93	476.65	67.30	127.20	67.30
South Africa	2003	10.38	503.53	66.31	124.36	66.31
South Africa	2004	10.98	537.91	66.14	127.03	66.14
South Africa	2005	11.11	549.82	66.14	118.38	66.14
South Africa	2006	11.08	553.96	66.91	117.19	66.91
South Africa	2007	11.40	576.07	74.04	109.05	74.04
South Africa	2008	11.86	606.04	69.99	93.00	69.99
South Africa	2009	11.10	574.17	71.07	91.81	71.07
South Africa	2010	11.13	582.48	72.45	90.96	72.45
South Africa	2011	10.62	562.87	71.09	142.42	71.09
South Africa	2012	10.84	583.02	65.42	139.01	65.42
South Africa	2013	10.89	595.40	59.76	122.28	59.76
South Africa	2014	10.95	608.85	55.04	112.82	55.04
South Africa	2015	10.28	583.29	53.93	102.77	53.93
South Africa	2016	10.19	583.29	52.12	97.32	52.12
South Africa	2017	10.33	595.32	64.98	127.03	64.98
South Africa	2018	10.20	598.07	66.55	125.17	66.55
South Africa	2019	10.12	602.85	67.83	118.97	67.83
South Africa	2020	8.94	541.71	68.17	124.09	68.17
South Africa	2021	8.96	550.98	69.71	121.09	69.71
South Africa	2022	8.55	533.03	73.30	125.96	73.30
South Africa	2023	8.26	522.12	51.42	121.07	51.42

Country	**YEAR**	**TURN**	**VASTR**	**CERS**	**CIF**	**IND**	**URB**
Côte d'Ivoire	2000	1.04	0.10	23342.1	13500	11.15	43.16
Côte d'Ivoire	2001	5.83	0.40	26843.42	13500	10.77	43.57
Côte d'Ivoire	2002	7.56	0.20	31943.66	13500	9.80	43.98
Côte d'Ivoire	2003	0.87	0.05	34818.59	13500	8.89	44.40
Côte d'Ivoire	2004	1.33	0.10	35457.47	13500	8.79	44.82
Côte d'Ivoire	2005	1.47	0.11	36415.78	18000	10.28	45.23
Côte d'Ivoire	2006	2.41	0.21	37693.52	18000	10.03	45.65
Côte d'Ivoire	2007	1.50	0.15	38000	18000	10.31	46.07
Côte d'Ivoire	2008	2.58	0.42	38000	18000	10.20	46.49
Côte d'Ivoire	2009	1.98	0.57	38000	18000	9.63	46.91
Côte d'Ivoire	2010	4.12	0.86	39500	18000	9.00	47.33
Côte d'Ivoire	2011	3.93	0.71	39500	18000	9.22	47.75
Côte d'Ivoire	2012	3.17	0.65	40245	21370	10.32	48.17
Côte d'Ivoire	2013	1.85	0.32	42836	22850	11.85	48.59
Côte d'Ivoire	2014	2.45	0.48	62873	23550	12.20	49.01
Côte d'Ivoire	2015	3.11	0.86	44570.73	24000	11.43	49.44
Côte d'Ivoire	2016	3.41	0.82	121157.05	24000	12.54	49.88
Côte d'Ivoire	2017	4.18	1.14	197534.12	24000	11.28	50.33
Côte d'Ivoire	2018	3.27	1.04	273911.2	24000	11.29	50.78
Côte d'Ivoire	2019	2.62	0.63	350288.27	24000	12.32	51.24
Côte d'Ivoire	2020	2.07	0.25	426874.59	34000	12.05	51.71
Côte d'Ivoire	2021	1.86	0.26	503460.91	34000	13.40	52.18
Côte d'Ivoire	2022	2.31	0.28	580047.23	38,354	14.37	52.03
Côte d'Ivoire	2023	2.31	0.28	656633.55	38,354	14.37	52.11

Ghana	2000	4.13	0.77	29836.12	22000	9.02	43.93
Ghana	2001	2.16	0.26	34311.53	28000	9.00	44.60
Ghana	2002	1.39	0.14	40830.73	28000	9.03	45.28
Ghana	2003	4.46	0.24	43280.57	28000	8.98	45.95
Ghana	2004	2.86	0.16	44146.18	28000	8.74	46.63
Ghana	2005	6.87	0.58	46794.95	28000	8.66	47.31
Ghana	2006	15.18	0.82	48198.8	36000	9.54	47.99
Ghana	2007	8.36	0.47	48680.79	36000	8.60	48.67
Ghana	2008	6.79	0.25	49167.6	42000	7.54	49.35
Ghana	2009	6.06	0.59	49659.27	42000	6.77	50.03
Ghana	2010	10.08	1.00	50000	42000	6.39	50.71
Ghana	2011	2.13	0.20	51000	42000	6.42	51.39
Ghana	2012	3.45	0.32	51441.58	50000	5.66	52.07
Ghana	2013	8.20	0.65	67838.15	50000	11.59	52.75
Ghana	2014	3.52	0.12	84866.54	50000	11.02	53.42
Ghana	2015	2.36	0.31	101894.92	50000	11.10	54.09
Ghana	2016	2.11	0.22	118969.96	50000	10.82	54.75
Ghana	2017	1.85	0.16	131302.06	50000	10.15	55.41
Ghana	2018	1.04	0.16	138989.07	50000	10.12	56.06
Ghana	2019	0.89	0.12	146676.07	50000	10.16	56.71
Ghana	2020	0.77	0.09	168396.1	50000	10.95	57.35
Ghana	2021	0.46	0.07	180116.13	67900	10.89	57.99
Ghana	2022	0.35	0.05	211836.16	69000	11.48	58.35
Ghana	2023	0.54	0.08	223556.19	56000	11.23	58.85
Kenya	2000	3.55	0.53	94762.4	32000	10.32	19.89
Kenya	2001	3.25	0.38	108976.8	32000	9.78	20.24
Kenya	2002	3.01	0.30	129682.3	32000	9.82	20.59
Kenya	2003	3.76	0.30	137463.3	32000	9.71	20.95
Kenya	2004	2.61	0.28	140212.5	32000	10.00	21.31
Kenya	2005	4.78	1.34	148625.3	46000	10.54	21.68
Kenya	2006	7.29	1.76	153084.1	46000	12.69	22.05
Kenya	2007	7.90	2.69	154614.9	48000	12.79	22.42
Kenya	2008	11.99	5.28	156161	48000	12.10	22.80
Kenya	2009	8.45	3.53	157722.7	48000	11.49	23.18
Kenya	2010	6.84	2.07	159299.9	50000	11.16	23.57
Kenya	2011	1.81	0.47	160892.9	50000	12.05	23.97
Kenya	2012	5.49	1.75	163383.44	50000	11.08	24.38
Kenya	2013	8.99	1.96	264497.12	50000	10.91	24.79
Kenya	2014	4.36	1.79	463160.21	82000	10.07	25.22
Kenya	2015	3.55	2.93	1158045.2	82100	9.98	25.66
Kenya	2016	3.12	1.48	1855663.8	82100	9.32	26.11
Kenya	2017	3.08	0.97	2548776.2	82100	8.74	26.56
Kenya	2018	2.78	1.09	3210013.3	82100	8.41	27.03
Kenya	2019	2.22	0.88	3871250.5	82100	7.90	27.51
Kenya	2020	2.09	0.65	4534299.2	102700	7.60	28.00
Kenya	2021	1.88	0.47	5197347.9	93400	7.36	28.49
Kenya	2022	2.26	0.48	5460396.6	93400	7.74	28.71
Kenya	2023	2.87	0.49	5823445.3	82100	7.60	29.28
Mauritius	2000	5.55	2.27	9663.496	21000	19.48	42.67
Mauritius	2001	4.65	1.63	11113.02	21000	19.77	42.56

Mauritius	2002	5.26	1.40	13224.49	21000	18.81	42.45
Mauritius	2003	10.77	2.28	14017.96	21000	17.79	42.34
Mauritius	2004	4.62	1.14	14298.32	21000	17.30	42.22
Mauritius	2005	5.42	1.76	15156.22	21000	16.67	42.11
Mauritius	2006	5.38	1.73	15610.91	19500	15.82	42.00
Mauritius	2007	6.01	2.15	15767.02	19500	15.47	41.89
Mauritius	2008	3.16	2.23	15924.69	19500	15.31	41.78
Mauritius	2009	5.20	5.05	16083.94	19500	14.91	41.67
Mauritius	2010	7.48	3.49	16244.77	22000	14.16	41.56
Mauritius	2011	5.17	3.73	16407.22	22000	13.87	41.44
Mauritius	2012	4.71	3.65	16661.2	27500	13.65	41.33
Mauritius	2013	6.50	4.43	23089.68	28100	13.72	41.22
Mauritius	2014	4.12	2.54	29518.16	28800	13.52	41.11
Mauritius	2015	3.59	2.65	35946.64	51750	13.01	41.00
Mauritius	2016	5.29	3.62	42392.73	51750	12.38	40.91
Mauritius	2017	6.37	3.94	48821.2	50000	11.84	40.84
Mauritius	2018	4.22	2.61	55249.68	50000	11.32	40.79
Mauritius	2019	4.61	3.39	61678.16	50000	10.52	40.77
Mauritius	2020	4.62	3.21	64328.81	60000	10.82	40.76
Mauritius	2021	4.33	2.66	66979.46	60000	11.70	40.78
Mauritius	2022	5.05	2.84	69630.11	60000	11.81	40.79
Mauritius	2023	4.19	2.99	70280.76	60000	11.05	40.81
Namibia	2000	3.04	0.34	7546.525	58000	9.74	32.37
Namibia	2001	3.36	0.58	8678.504	58000	9.62	32.90
Namibia	2002	6.11	0.47	10327.42	58000	9.42	33.77
Namibia	2003	3.46	0.15	10947.06	58000	11.39	34.71
Namibia	2004	1.95	0.05	11166.01	58000	10.59	35.67
Namibia	2005	3.97	0.06	11835.97	75000	10.49	36.63
Namibia	2006	21.55	0.30	12191.05	75000	12.59	37.61
Namibia	2007	4.55	0.08	12312.96	75000	13.47	38.60
Namibia	2008	10.96	0.22	12436.09	75000	11.27	39.60
Namibia	2009	11.80	0.23	12560.45	75000	12.86	40.60
Namibia	2010	30.10	0.17	12686.05	83000	12.30	41.62
Namibia	2011	80.38	0.28	12812.91	83000	13.46	42.64
Namibia	2012	17.54	0.18	13011.25	91000	12.19	43.69
Namibia	2013	11.23	0.10	17380.25	91000	10.32	44.76
Namibia	2014	12.47	0.46	21749.26	131250	9.91	45.83
Namibia	2015	10.37	0.28	26118.26	131250	11.42	46.90
Namibia	2016	8.35	0.56	105114.45	150000	11.68	47.96
Namibia	2017	10.36	0.55	232716.74	150000	12.22	49.01
Namibia	2018	7.26	0.61	360319.02	150000	12.30	50.03
Namibia	2019	4.44	0.66	487921.31	150000	12.46	51.04
Namibia	2020	4.87	0.73	611605.93	162000	11.02	52.03
Namibia	2021	3.76	0.78	635290.55	165000	10.78	53.01
Namibia	2022	1.95	0.35	658975.17	165000	11.11	53.48
Namibia	2023	2.77	0.69	682659.79	150000	11.23	53.49
Nigeria	2000	5.91	1.12	326209.3	125000	13.93	34.84
Nigeria	2001	3.83	0.19	375140.7	125000	13.93	35.67
Nigeria	2002	5.26	0.88	446417.4	125000	11.81	36.51
Nigeria	2003	6.26	0.23	473202.4	125000	12.06	37.36

Nigeria	2004	6.84	0.67	482666.5	125000	10.86	38.21
Nigeria	2005	8.69	1.00	511626.5	125000	10.06	39.07
Nigeria	2006	10.59	1.23	526975.3	186000	8.85	39.94
Nigeria	2007	8.78	1.11	532245	194000	8.40	40.82
Nigeria	2008	10.96	1.52	537567.5	194000	8.17	41.70
Nigeria	2009	20.45	6.30	542943.2	194000	7.84	42.59
Nigeria	2010	34.79	4.92	548372.6	205000	6.55	43.48
Nigeria	2011	13.94	1.52	553856.3	205000	7.17	44.37
Nigeria	2012	10.10	1.41	562429.79	250000	7.72	45.25
Nigeria	2013	9.92	0.96	870409.53	250000	8.93	46.12
Nigeria	2014	7.28	0.90	1178389.3	250000	9.64	46.98
Nigeria	2015	7.73	1.22	1486369	250000	9.43	47.84
Nigeria	2016	8.18	0.94	1795192.5	250000	8.68	48.68
Nigeria	2017	8.17	0.84	2102864.8	250000	8.74	49.52
Nigeria	2018	5.07	0.37	2403937.5	250000	9.65	50.34
Nigeria	2019	5.93	0.59	2702856.9	250000	11.52	51.16
Nigeria	2020	8.20	0.65	2949688.5	295000	12.67	51.96
Nigeria	2021	6.19	0.61	3196520.1	295000	14.61	52.75
Nigeria	2022	4.39	0.57	3443351.8	300000	13.59	53.53
Nigeria	2023	7.02	0.63	3690183.4	300000	15.36	54.32
South Africa	2000	32.21	35.48	4112932	350000	18.97	56.89
South Africa	2001	28.04	48.06	4729872	350000	19.04	57.37
South Africa	2002	34.51	46.46	5628548	350000	19.07	57.90
South Africa	2003	23.98	26.11	5966261	350000	18.50	58.45
South Africa	2004	26.20	36.94	6085586	350000	17.99	58.99
South Africa	2005	18.81	24.90	6450721	350000	17.37	59.54
South Africa	2006	18.93	32.75	6644243	400000	15.60	60.08
South Africa	2007	20.26	38.53	6710685	400000	15.44	60.62
South Africa	2008	24.43	57.18	6777792	400000	15.61	61.15
South Africa	2009	31.12	77.38	6845570	400000	14.51	61.69
South Africa	2010	41.98	64.10	6914026	400000	13.86	62.22
South Africa	2011	27.22	65.96	6983166	400000	12.86	62.75
South Africa	2012	29.97	66.42	7091262.9	500000	12.48	63.27
South Africa	2013	28.62	49.29	8714279.4	500000	12.37	63.79
South Africa	2014	24.99	52.22	10288384	500000	12.48	64.31
South Africa	2015	24.63	57.93	11643519	500000	12.52	64.83
South Africa	2016	26.31	64.45	12968703	500000	12.48	65.34
South Africa	2017	31.79	67.49	14306160	500000	12.51	65.85
South Africa	2018	42.30	124.37	15389389	500000	12.46	66.36
South Africa	2019	33.28	107.41	16440196	500000	12.40	66.86
South Africa	2020	34.09	72.87	17483622	700000	11.73	67.35
South Africa	2021	26.96	73.42	18527047	700000	12.06	67.85
South Africa	2022	27.94	87.60	19570473	700000	12.43	68.34
South Africa	2023	28.46	88.36	19613899	500000	12.96	68.83

Source: World Bank Development indicators (WBDI) and international Monetary Fund (IMF) Financial Structure Database (2023)

Appendix III

Regression Results

Dependent Variable: D(LGHG)
Method: ARDL
Date: 03/27/25 Time: 17:41
Sample: 2001 2023
Included observations: 161
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (1 lag, automatic): BC_GDP FINL TURN VASTR LCERS LCIF LMVA URB
Fixed regressors: C
Number of models evalulated: 1
Selected Model: ARDL(1, 1, 1, 1, 1, 1, 1, 1, 1)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
		Long Run Equation		
BC_GDP	0.011285	0.003839	2.939609	0.0042
FINL	0.005163	0.004091	1.262280	0.2101
TURN	0.006147	0.003731	1.647674	0.1029
VASTR	-0.002082	0.003875	-0.537289	0.5924
LCERS	-0.090290	0.017268	-5.228819	0.0000
LCIF	-0.402935	0.098629	-4.085376	0.0001
LMVA	1.189423	0.182941	6.501689	0.0000
URB	0.010809	0.011361	0.951436	0.3439
		Short Run Equation		
COINTEQ01	-0.203976	0.098210	-2.026117	0.0501
D(BC_GDP)	-0.004067	0.003630	-1.120365	0.2655
D(FINL)	0.002462	0.003373	0.729985	0.4673
D(TURN)	0.002140	0.002149	0.995800	0.3220
D(VASTR)	-0.013476	0.006540	-2.060651	0.0422
D(LCERS)	-0.020633	0.030289	-0.681197	0.4975
D(LCIF)	-0.043782	0.079614	-0.549932	0.5837
D(LMVA)	-0.097488	0.273467	-0.356491	0.7223
D(URB)	0.245768	0.174621	1.407438	0.1627
C	-2.307095	1.209746	-1.907090	0.0597

Mean dependent var	0.024597	S.D. dependent var	0.054952
S.E. of regression	0.041946	Akaike info criterion	-3.129988
Sum squared resid	0.158352	Schwarz criterion	-1.679576
Log likelihood	340.9190	Hannan-Quinn criter.	-2.541341

*Note: p-values and any subsequent tests do not account for model selection.

Dependent Variable: D(LGHG)
Method: ARDL
Date: 03/17/25 Time: 17:20
Sample: 2001 2023
Included observations: 161
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): BC_GDP FINL LMVA URB
Fixed regressors: C
Number of models evaluated: 2
Selected Model: ARDL(1, 1, 1, 1, 1)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
	Long Run Equation			
BC_GDP	-0.010648	0.004332	-2.458213	0.0154
FINL	-0.000366	0.002172	-0.168625	0.8664
LMVA	0.082484	0.033663	2.450260	0.0157
URB	0.066472	0.004460	14.90550	0.0000
	Short Run Equation			
COINTEQ01	-0.235980	0.143218	-1.647697	0.1020
D(BC_GDP)	-0.001695	0.003759	-0.450916	0.6529
D(FINL)	0.003728	0.003391	1.099310	0.2738
D(LMVA)	0.048542	0.194465	0.249616	0.8033
D(URB)	0.132997	0.076840	1.730836	0.0860
C	-0.084460	0.157691	-0.535606	0.5932

Mean dependent var	0.024597	S.D. dependent var	0.054952
S.E. of regression	0.047981	Akaike info criterion	-3.131138
Sum squared resid	0.280862	Schwarz criterion	-2.275767
Log likelihood	309.0156	Hannan-Quinn criter.	-2.783986

*Note: p-values and any subsequent tests do not account for model selection.

Dependent Variable: D(LGHG)
Method: ARDL
Date: 03/17/25 Time: 17:22
Sample: 2003 2023
Included observations: 147
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (3 lags, automatic): LMVA URB TURN VASTR
Fixed regressors: C
Number of models evaluated: 3
Selected Model: ARDL(1, 3, 3, 3, 3)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
	Long Run Equation			

LMVA	0.526176	0.082175	6.403097	0.0000
URB	-0.042433	0.005281	-8.034576	0.0000
TURN	-0.002078	0.007541	-0.275580	0.7837
VASTR	-0.039235	0.015800	-2.206595	0.0391
		Short Run Equation		
COINTEQ01	-0.227765	0.062589	-3.597354	0.0150
D(LMVA)	0.224234	0.109795	2.042292	0.0451
D(LMVA(-1))	0.220838	0.287804	0.767320	0.4456
D(LMVA(-2))	0.230584	0.116313	1.982445	0.0516
D(URB)	-1.838301	1.327161	-1.385137	0.1707
D(URB(-1))	2.470987	1.532551	1.612336	0.1117
D(URB(-2))	-0.883365	0.732172	-1.206500	0.2319
D(TURN)	0.004907	0.003082	1.592196	0.1161
D(TURN(-1))	-0.004298	0.003185	-1.349328	0.1818
D(TURN(-2))	-0.001825	0.005017	-0.363838	0.7171
D(VASTR)	-0.064614	0.023066	-2.801246	0.0067
D(VASTR(-1))	-0.045970	0.050821	-0.904538	0.3690
D(VASTR(-2))	0.023628	0.033415	0.707089	0.4820
C	0.651963	0.748834	0.870638	0.3871

Mean dependent var	0.025316	S.D. dependent var	0.055121
S.E. of regression	0.042605	Akaike info criterion	-3.085993
Sum squared resid	0.119800	Schwarz criterion	-1.189301
Log likelihood	361.2234	Hannan-Quinn criter.	-2.316223

*Note: p-values and any subsequent tests do not account for model selection.

Dependent Variable: D(LGHG)
Method: ARDL
Date: 03/17/25 Time: 17:25
Sample: 2003 2023
Included observations: 147
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (3 lags, automatic): LCERS LCIF LMVA URB
Fixed regressors: C
Number of models evalulated: 3
Selected Model: ARDL(1, 3, 3, 3, 3)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
		Long Run Equation		
LCERS	0.001455	0.010583	0.137517	0.8910
LCIF	-0.324917	0.049885	-6.513261	0.0000
LMVA	0.801364	0.044268	18.10270	0.0000
URB	-0.021657	0.005494	-3.941698	0.0002
		Short Run Equation		
COINTEQ01	-0.426826	0.133446	-3.248374	0.0120

D(LCERS)	-0.012704	0.071845	-0.176825	0.8602
D(LCERS(-1))	-0.161243	0.088981	-1.812114	0.0745
D(LCERS(-2))	-0.038615	0.058109	-0.664526	0.5087
D(LCIF)	0.184687	0.048994	3.769594	0.0004
D(LCIF(-1))	0.001713	0.046893	0.036525	0.9710
D(LCIF(-2))	0.137133	0.111543	1.229420	0.2233
D(LMVA)	-0.158192	0.228515	-0.692261	0.4912
D(LMVA(-1))	-0.144742	0.058296	-2.482884	0.0156
D(LMVA(-2))	-0.088441	0.250934	-0.352446	0.7256
D(URB)	-1.237304	1.631841	-0.758226	0.4510
D(URB(-1))	0.278488	0.932943	0.298504	0.7663
D(URB(-2))	0.760941	0.424003	1.794661	0.0773
C	1.380351	1.236072	1.116724	0.2682

Mean dependent var	0.025316	S.D. dependent var	0.055121
S.E. of regression	0.043883	Akaike info criterion	-3.140462
Sum squared resid	0.127099	Schwarz criterion	-1.243770
Log likelihood	365.7988	Hannan-Quinn criter.	-2.370692

*Note: p-values and any subsequent tests do not account for model selection.

Robust Estimates (PCSE)

Dependent Variable: LGHG
Method: Panel EGLS (Cross-section weights)
Date: 03/27/25 Time: 17:40
Sample: 2000 2023
Periods included: 24
Cross-sections included: 7
Total panel (balanced) observations: 168
Linear estimation after one-step weighting matrix
Period weights (PCSE) standard errors & covariance (d.f. corrected)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-8.207225	0.282105	-29.09281	0.0000
BC_GDP	0.003702	0.001011	3.661919	0.0003
FINL	-0.007074	0.001146	-6.174988	0.0000
TURN	-0.002217	0.001597	-1.388015	0.1671
VASTR	0.003876	0.001308	2.963630	0.0035
LCERS	-0.019165	0.014135	-1.355853	0.1771
LCIF	-0.422569	0.029842	-14.16027	0.0000
LMVA	1.029856	0.025676	40.10988	0.0000
URB	-0.028096	0.001139	-24.67013	0.0000

Weighted Statistics

R-squared	0.986773	Mean dependent var	4.818945
Adjusted R-squared	0.986108	S.D. dependent var	2.804224
S.E. of regression	0.208020	Sum squared resid	6.880283
F-statistic	1482.755	Durbin-Watson stat	0.356540
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.982792	Mean dependent var	3.835886
Sum squared resid	7.959366	Durbin-Watson stat	0.200400

Dependent Variable: LGHG
Method: Panel EGLS (Cross-section weights)
Date: 03/27/25 Time: 17:36
Sample: 2000 2023
Periods included: 24
Cross-sections included: 7
Total panel (balanced) observations: 168
Linear estimation after one-step weighting matrix
Period weights (PCSE) standard errors & covariance (d.f. corrected)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-6.088603	0.220427	-27.62189	0.0000
BC_GDP	0.010201	0.001003	10.16683	0.0000
FINL	-0.009827	0.001524	-6.448916	0.0000
LMVA	1.274555	0.023664	53.85990	0.0000
URB	-0.026658	0.001569	-16.98883	0.0000

Weighted Statistics

R-squared	0.970949	Mean dependent var	4.917633
Adjusted R-squared	0.970236	S.D. dependent var	3.195457
S.E. of regression	0.301794	Sum squared resid	14.84596
F-statistic	1361.938	Durbin-Watson stat	0.231066
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.964299	Mean dependent var	3.835886
Sum squared resid	16.51347	Durbin-Watson stat	0.147209

Dependent Variable: LGHG
Method: Panel EGLS (Cross-section weights)
Date: 03/27/25 Time: 17:39
Sample: 2000 2023
Periods included: 24
Cross-sections included: 7
Total panel (balanced) observations: 168
Linear estimation after one-step weighting matrix
Period weights (PCSE) standard errors & covariance (d.f. corrected)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-9.532194	0.195596	-48.73413	0.0000
LCERS	-0.015089	0.016419	-0.918973	0.3595
LCIF	-0.477769	0.025671	-18.61151	0.0000
LMVA	1.076620	0.026685	40.34519	0.0000
URB	-0.024880	0.001186	-20.98108	0.0000

Weighted Statistics			
R-squared	0.989147	Mean dependent var	5.547884
Adjusted R-squared	0.988880	S.D. dependent var	3.889827
S.E. of regression	0.232759	Sum squared resid	8.830844
F-statistic	3713.807	Durbin-Watson stat	0.236790
Prob(F-statistic)	0.000000		

Unweighted Statistics			
R-squared	0.973619	Mean dependent var	3.835886
Sum squared resid	12.20279	Durbin-Watson stat	0.098045

UNIT ROOT TESTS

Panel unit root test: Summary
Series: LGHG
Date: 03/17/25 Time: 17:26
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-0.91251	0.1808	7	154
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	0.74631	0.7723	7	154
ADF - Fisher Chi-square	10.9253	0.6919	7	154
PP - Fisher Chi-square	12.3979	0.5744	7	161

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: D(LGHG)
Date: 03/17/25 Time: 17:27
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-4.26820	0.0000	7	147

Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-5.01224	0.0000	7	147
ADF - Fisher Chi-square	51.7390	0.0000	7	147
PP - Fisher Chi-square	219.130	0.0000	7	154

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: FINL
Date: 03/17/25 Time: 17:27
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-0.03175	0.4873	7	154
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-1.61552	0.0531	7	154
ADF - Fisher Chi-square	20.3462	0.1196	7	154
PP - Fisher Chi-square	33.2116	0.0027	7	161

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: D(FINL)
Date: 03/17/25 Time: 17:27
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.74397	0.0030	7	147
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-5.22323	0.0000	7	147
ADF - Fisher Chi-square	54.8251	0.0000	7	147
PP - Fisher Chi-square	333.556	0.0000	7	154

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: BC_GDP
Date: 03/17/25 Time: 17:28
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.17414	0.1202	7	154
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-2.52155	0.0058	7	154
ADF - Fisher Chi-square	28.5394	0.0121	7	154
PP - Fisher Chi-square	31.2970	0.0050	7	161

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: D(BC_GDP)
Date: 03/17/25 Time: 17:28
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-5.54022	0.0000	7	147
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-6.51957	0.0000	7	147
ADF - Fisher Chi-square	67.2181	0.0000	7	147
PP - Fisher Chi-square	129.754	0.0000	7	154

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: TURN
Date: 03/17/25 Time: 17:28
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-3.72830	0.0001	7	154
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-3.59032	0.0002	7	154
ADF - Fisher Chi-square	38.6288	0.0004	7	154
PP - Fisher Chi-square	47.5510	0.0000	7	161

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: D(TURN)
Date: 03/17/25 Time: 17:29
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-8.98975	0.0000	7	147
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-9.49196	0.0000	7	147
ADF - Fisher Chi-square	99.5416	0.0000	7	147
PP - Fisher Chi-square	221.270	0.0000	7	154

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: VASTR
Date: 03/17/25 Time: 17:29
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.96223	0.0249	7	154

Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-1.82824	0.0366	7	154
ADF - Fisher Chi-square	19.4280	0.1492	7	154
PP - Fisher Chi-square	25.3926	0.0309	7	161

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: D(VASTR)
Date: 03/17/25 Time: 17:30
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-7.77610	0.0000	7	147
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-8.16057	0.0000	7	147
ADF - Fisher Chi-square	84.9464	0.0000	7	147
PP - Fisher Chi-square	157.822	0.0000	7	154

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: LCERS
Date: 03/17/25 Time: 17:30
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	0.77124	0.7797	7	154
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	3.72855	0.9999	7	154
ADF - Fisher Chi-square	1.42200	1.0000	7	154
PP - Fisher Chi-square	0.78088	1.0000	7	161

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: D(LCERS)
Date: 03/17/25 Time: 17:30
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.76054	0.0344	7	147
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-1.85513	0.0318	7	147
ADF - Fisher Chi-square	21.7206	0.0845	7	147
PP - Fisher Chi-square	33.6433	0.0023	7	154

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: LCIF
Date: 03/17/25 Time: 17:31
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-0.26777	0.3944	7	154
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	1.88826	0.9705	7	154
ADF - Fisher Chi-square	4.49675	0.9917	7	154
PP - Fisher Chi-square	7.10339	0.9307	7	161

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: D(LCIF)
Date: 03/17/25 Time: 17:31
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.29630	0.0108	7	147
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-4.86237	0.0000	7	147
ADF - Fisher Chi-square	49.5721	0.0000	7	147
PP - Fisher Chi-square	102.760	0.0000	7	154

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: URB
Date: 03/17/25 Time: 17:32
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-24.9664	0.0000	7	154
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-14.1014	0.0000	7	154
ADF - Fisher Chi-square	306.760	0.0000	7	154
PP - Fisher Chi-square	21.7639	0.0836	7	161

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: LMVA
Date: 03/17/25 Time: 17:32
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.10513	0.1346	7	154
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	1.01632	0.8453	7	154
ADF - Fisher Chi-square	11.1737	0.6723	7	154
PP - Fisher Chi-square	12.5977	0.5584	7	161

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: D(LMVA)
Date: 03/17/25 Time: 17:32
Sample: 2000 2023
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-5.99060	0.0000	7	147
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-5.26127	0.0000	7	147
ADF - Fisher Chi-square	53.8776	0.0000	7	147
PP - Fisher Chi-square	90.5582	0.0000	7	154

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Cointegration Test

Pedroni Residual Cointegration Test
Series: LGHG BC_GDP FINL LMVA URB
Date: 03/17/25   Time: 17:33
Sample: 2000 2023
Included observations: 168
Cross-sections included: 7
Null Hypothesis: No cointegration
Trend assumption: No deterministic trend
User-specified lag length: 1
Newey-West automatic bandwidth selection and Bartlett kernel

Alternative hypothesis: common AR coefs. (within-dimension)

	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-0.476905	0.6833	-0.718629	0.7638
Panel rho-Statistic	0.288835	0.6136	-0.190666	0.4244
Panel PP-Statistic	-2.069207	0.0193	-3.615030	0.0002
Panel ADF-Statistic	-1.973370	0.0352	-2.107183	0.0176

Alternative hypothesis: individual AR coefs. (between-dimension)

	Statistic	Prob.
Group rho-Statistic	1.401204	0.9194
Group PP-Statistic	-2.269828	0.0116
Group ADF-Statistic	-2.277125	0.0114

Pedroni Residual Cointegration Test
Series: LGHG LMVA URB TURN VASTR
Date: 03/17/25   Time: 17:35
Sample: 2000 2023
Included observations: 168
Cross-sections included: 7
Null Hypothesis: No cointegration
Trend assumption: No deterministic trend
User-specified lag length: 1
Newey-West automatic bandwidth selection and Bartlett kernel

Alternative hypothesis: common AR coefs. (within-dimension)

	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-0.249836	0.5986	-0.716478	0.7632
Panel rho-Statistic	0.476601	0.6832	0.677286	0.7509
Panel PP-Statistic	-1.719906	0.0471	-1.782585	0.0418
Panel ADF-Statistic	-1.118589	0.1317	-1.915536	0.0277

Alternative hypothesis: individual AR coefs. (between-dimension)

	Statistic	Prob.
Group rho-Statistic	1.967043	0.9754
Group PP-Statistic	-0.554161	0.2897
Group ADF-Statistic	-1.703293	0.0464

Kao Residual Cointegration Test
Series: LGHG LMVA URB TURN VASTR
Date: 03/17/25 Time: 17:36
Sample: 2000 2023
Included observations: 168
Null Hypothesis: No cointegration
Trend assumption: No deterministic trend
User-specified lag length: 1
Newey-West automatic bandwidth selection and Bartlett kernel

	t-Statistic	Prob.
ADF	-2.079136	0.0188
Residual variance	0.002996	
HAC variance	0.005029	

Pedroni Residual Cointegration Test
Series: LGHG LMVA URB LCERS LCIF
Date: 03/17/25 Time: 17:37
Sample: 2000 2023
Included observations: 168
Cross-sections included: 7
Null Hypothesis: No cointegration
Trend assumption: No deterministic trend
User-specified lag length: 1
Newey-West automatic bandwidth selection and Bartlett kernel

Alternative hypothesis: common AR coefs. (within-dimension)

	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-0.543226	0.7065	-0.490234	0.6880
Panel rho-Statistic	0.899716	0.8159	1.074771	0.8588
Panel PP-Statistic	-1.384519	0.0831	-1.342375	0.0897
Panel ADF-Statistic	-2.278370	0.0114	-2.435919	0.0074

Alternative hypothesis: individual AR coefs. (between-dimension)

	Statistic	Prob.
Group rho-Statistic	2.153494	0.9844
Group PP-Statistic	-3.071306	0.0011
Group ADF-Statistic	-3.055014	0.0011

CIPS unit root test for GHG
Null hypothesis: Unit root

Test results:

Statistic	t-stat	p-value
CIPS:	-1.37635	>=0.05
Truncated CIPS:	-1.53268	>0.05

Critical values:

Level	CIPS	Trunc. CIPS
1%	-2.59	-2.59
5%	-2.34	-2.34
10%	-2.21	-2.21

CIPS unit root test for D(GHG)
Null hypothesis: Unit root

Test results:

Statistic	t-stat	p-value
CIPS:	-2.86436	<0.05
Truncated CIPS:	-2.36900	<0.05

Critical values:

Level	CIPS	Trunc. CIPS
1%	-2.59	-2.59
5%	-2.34	-2.34
10%	-2.21	-2.21

Appendix IV

Individual Country Results

Cote d'Ivoire

Levels Equation Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
BC_GDP	0.023923	0.009993	2.394069	0.0479
FINL	-0.015035	0.004541	-3.310806	0.0129
TURN	0.035973	0.008660	4.154091	0.0043
VASTR	-0.201712	0.070245	-2.871558	0.0239
LCERS	-0.012421	0.022665	-0.548005	0.6007
LCIF	-0.314068	0.135376	-2.319974	0.0534
MVA	-1.43E-05	1.31E-05	-1.094442	0.3100
URB	0.148579	0.027614	5.380631	0.0010
C	-0.683584	0.403489	-1.694184	0.1341

EC = LGHG - (0.0239*BC_GDP -0.0150*FINL + 0.0360*TURN -0.2017
*VASTR -0.0124*LCERS -0.3141*LCIF -0.0000*MVA + 0.1486*URB
-0.6836)

ARDL Error Correction Regression
Dependent Variable: D(LGHG)
Selected Model: ARDL(1, 1, 1, 0, 1, 0, 1, 1, 1)
Case 2: Restricted Constant and No Trend
Date: 09/02/25 Time: 22:04
Sample: 2000 2023
Included observations: 23

ECM Regression Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BC_GDP)	0.004198	0.001637	2.564459	0.0373
D(FINL)	0.001125	0.000922	1.220281	0.2619
D(VASTR)	-0.096866	0.011069	-8.750848	0.0001
D(LCIF)	-0.102319	0.020498	-4.991660	0.0016
D(MVA)	1.72E-05	3.95E-06	4.352439	0.0033
D(URB)	0.086974	0.005346	16.26901	0.0000
CointEq(-1)*	-0.815660	0.036623	-22.27184	0.0000

R-squared	0.975158	Mean dependent var	0.029129
Adjusted R-squared	0.965842	S.D. dependent var	0.041525
S.E. of regression	0.007675	Akaike info criterion	-6.656003
Sum squared resid	0.000942	Schwarz criterion	-6.310418
Log likelihood	83.54404	Hannan-Quinn criter.	-6.569089
Durbin-Watson stat	3.172818		

* p-value incompatible with t-Bounds distribution.

Ghana

ARDL Error Correction Regression
Dependent Variable: D(LGHG)
Selected Model: ARDL(1, 0, 0, 0, 0, 1, 0, 0, 0)
Case 2: Restricted Constant and No Trend
Date: 09/02/25 Time: 22:08
Sample: 2000 2023
Included observations: 23

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCERS)	0.100606	0.037837	2.658924	0.0208
CointEq(-1)*	-0.645994	0.053263	-12.12836	0.0000

R-squared	0.746721	Mean dependent var	0.050037
Adjusted R-squared	0.734660	S.D. dependent var	0.037386
S.E. of regression	0.019258	Akaike info criterion	-4.978843
Sum squared resid	0.007788	Schwarz criterion	-4.880104
Log likelihood	59.25669	Hannan-Quinn criter.	-4.954010
Durbin-Watson stat	1.846093		

* p-value incompatible with t-Bounds distribution.

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BC_GDP	0.008983	0.006130	1.465505	0.1685
FINL	-0.003846	0.004883	-0.787620	0.4462
TURN	-5.59E-05	0.006020	-0.009284	0.9927
VASTR	-0.004773	0.082628	-0.057767	0.9549
LCERS	-0.174813	0.094592	-1.848083	0.0894
LCIF	0.098360	0.120342	0.817337	0.4297
LMVA	0.317301	0.323000	0.982356	0.3453
URB	0.084838	0.026306	3.225010	0.0073
C	-2.904986	2.277774	-1.275362	0.2263

EC = LGHG - (0.0090*BC_GDP -0.0038*FINL -0.0001*TURN -0.0048
*VASTR -0.1748*LCERS + 0.0984*LCIF + 0.3173*LMVA + 0.0848
*URB -2.9050)

Kenya

ARDL Error Correction Regression
Dependent Variable: D(LGHG)
Selected Model: ARDL(1, 1, 0, 0, 1, 1, 0, 0, 0)
Case 2: Restricted Constant and No Trend
Date: 09/02/25 Time: 22:10
Sample: 2000 2023
Included observations: 23

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BC_GDP)	-0.029305	0.003724	-7.868703	0.0000
D(VASTR)	0.050960	0.008379	6.082256	0.0001
D(LCERS)	-0.294504	0.043974	-6.697207	0.0001
CointEq(-1)*	-0.963093	0.095475	-10.08738	0.0000

R-squared	0.807634	Mean dependent var	0.041804
Adjusted R-squared	0.777261	S.D. dependent var	0.074985
S.E. of regression	0.035389	Akaike info criterion	-3.688050
Sum squared resid	0.023795	Schwarz criterion	-3.490573
Log likelihood	46.41258	Hannan-Quinn criter.	-3.638385
Durbin-Watson stat	2.033247		

* p-value incompatible with t-Bounds distribution.

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BC_GDP	-0.023880	0.013430	-1.778129	0.1057
FINL	0.043668	0.022048	1.980561	0.0758
TURN	-0.007596	0.013387	-0.567421	0.5829
VASTR	0.082862	0.025183	3.290370	0.0081
LCERS	-0.033314	0.048972	-0.680272	0.5118
LCIF	-0.010831	0.123463	-0.087728	0.9318
LMVA	-0.272693	0.567039	-0.480907	0.6409
URB	0.145845	0.048907	2.982102	0.0138
C	2.644209	3.998640	0.661277	0.5234

EC = LGHG - (-0.0239*BC_GDP + 0.0437*FINL -0.0076*TURN + 0.0829
*VASTR -0.0333*LCERS -0.0108*LCIF -0.2727*LMVA + 0.1458*URB
+ 2.6442)

Mauritius

ARDL Error Correction Regression
Dependent Variable: D(LGHG)
Selected Model: ARDL(1, 1, 0, 1, 0, 1, 0, 0, 0)
Case 2: Restricted Constant and No Trend
Date: 09/02/25 Time: 22:12
Sample: 2000 2023
Included observations: 23

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BC_GDP)	-0.000196	0.000233	-0.841195	0.4199
D(TURN)	0.000649	0.001683	0.385679	0.7078
D(LCERS)	-0.121823	0.037563	-3.243129	0.0088
CointEq(-1)*	-0.842974	0.069544	-12.12152	0.0000

R-squared	0.854773	Mean dependent var	0.028180
Adjusted R-squared	0.831842	S.D. dependent var	0.043279
S.E. of regression	0.017747	Akaike info criterion	-5.068386
Sum squared resid	0.005984	Schwarz criterion	-4.870908
Log likelihood	62.28643	Hannan-Quinn criter.	-5.018721
Durbin-Watson stat	2.929152		

* p-value incompatible with t-Bounds distribution.

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BC_GDP	-0.002217	0.000993	-2.232240	0.0497
FINL	0.000473	0.000611	0.773830	0.4569
TURN	-0.013119	0.008673	-1.512632	0.1613
VASTR	-0.030387	0.017522	-1.734229	0.1135
LCERS	0.088490	0.064854	1.364442	0.2023
LCIF	-0.226348	0.101053	-2.239892	0.0490
LMVA	0.486279	0.167705	2.899604	0.0158
URB	-0.340032	0.055602	-6.115494	0.0001
C	13.89631	3.369566	4.124065	0.0021

EC = LGHG - (-0.0022*BC_GDP + 0.0005*FINL -0.0131*TURN -0.0304
*VASTR + 0.0885*LCERS -0.2263*LCIF + 0.4863*LMVA -0.3400
*URB + 13.8963)

Namibia

ARDL Error Correction Regression
Dependent Variable: D(LGHG)
Selected Model: ARDL(1, 0, 0, 1, 1, 0, 1, 1, 0)
Case 2: Restricted Constant and No Trend
Date: 09/02/25 Time: 22:13
Sample: 2000 2023
Included observations: 23

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(TURN)	-0.000418	0.000331	-1.261604	0.2388
D(VASTR)	-0.105326	0.031125	-3.384033	0.0081
D(LCIF)	0.314902	0.053941	5.837926	0.0002
D(LMVA)	0.161070	0.085704	1.879383	0.0929
CointEq(-1)*	-1.024267	0.105297	-9.727408	0.0000

R-squared	0.901296	Mean dependent var	0.018913
Adjusted R-squared	0.879362	S.D. dependent var	0.070354
S.E. of regression	0.024436	Akaike info criterion	-4.395838
Sum squared resid	0.010748	Schwarz criterion	-4.148991
Log likelihood	55.55214	Hannan-Quinn criter.	-4.333757
Durbin-Watson stat	3.008766		

* p-value incompatible with t-Bounds distribution.

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BC_GDP	-0.015154	0.008636	-1.754727	0.1132
FINL	0.001475	0.002285	0.645329	0.5348
TURN	0.002395	0.001704	1.405633	0.1934
VASTR	-0.329209	0.146174	-2.252178	0.0508
LCERS	0.020296	0.022232	0.912902	0.3851
LCIF	0.484390	0.167415	2.893354	0.0178
LMVA	-0.443173	0.365418	-1.212784	0.2561
URB	0.009489	0.011732	0.808752	0.4395
C	0.311474	1.704399	0.182747	0.8590

EC = LGHG - (-0.0152*BC_GDP + 0.0015*FINL + 0.0024*TURN -0.3292
*VASTR + 0.0203*LCERS + 0.4844*LCIF -0.4432*LMVA + 0.0095
*URB + 0.3115)

Nigeria

ARDL Error Correction Regression
Dependent Variable: D(LGHG)
Selected Model: ARDL(1, 1, 1, 0, 0, 1, 1, 1, 1)
Case 2: Restricted Constant and No Trend
Date: 09/02/25 Time: 22:15
Sample: 2000 2023
Included observations: 23

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BC_GDP)	0.000181	0.001843	0.098344	0.9244
D(FINL)	0.000383	0.001497	0.256093	0.8052
D(LCERS)	-0.215449	0.041849	-5.148207	0.0013
D(LCIF)	-0.352939	0.042158	-8.371801	0.0001
D(LMVA)	-0.076536	0.057761	-1.325028	0.2268
D(URB)	-2.573364	0.196256	-13.11229	0.0000
CointEq(-1)*	-1.146951	0.087007	-13.18222	0.0000

R-squared	0.926896	Mean dependent var	-0.002223
Adjusted R-squared	0.899482	S.D. dependent var	0.051605
S.E. of regression	0.016361	Akaike info criterion	-5.142038
Sum squared resid	0.004283	Schwarz criterion	-4.796453
Log likelihood	66.13344	Hannan-Quinn criter.	-5.055124
Durbin-Watson stat	2.450962		

* p-value incompatible with t-Bounds distribution.

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BC_GDP	-0.008358	0.004033	-2.072218	0.0770
FINL	0.002749	0.004045	0.679693	0.5185
TURN	0.000421	0.002297	0.183260	0.8598
VASTR	-0.015917	0.010308	-1.544106	0.1665
LCERS	-0.327166	0.147071	-2.224548	0.0615
LCIF	-0.427947	0.111612	-3.834228	0.0064
LMVA	0.270435	0.141331	1.913489	0.0973
URB	0.045198	0.017367	2.602573	0.0353
C	12.82531	2.023148	6.339283	0.0004

EC = LGHG - (-0.0084*BC_GDP + 0.0027*FINL + 0.0004*TURN -0.0159 *VASTR -0.3272*LCERS -0.4279*LCIF + 0.2704*LMVA + 0.0452 *URB + 12.8253)

South Africa

ARDL Error Correction Regression
Dependent Variable: D(LGHG)
Selected Model: ARDL(1, 1, 1, 1, 0, 0, 0, 0, 1)
Case 2: Restricted Constant and No Trend
Date: 09/02/25 Time: 22:16
Sample: 2000 2023
Included observations: 23

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BC_GDP)	-0.000960	0.000275	-3.485125	0.0069
D(FINL)	0.002355	0.000550	4.283361	0.0020
D(TURN)	0.000147	0.000590	0.249178	0.8088
D(URB)	1.617508	0.171561	9.428188	0.0000
CointEq(-1)*	-0.661056	0.070627	-9.359759	0.0000

R-squared	0.850865	Mean dependent var	0.006342
Adjusted R-squared	0.817724	S.D. dependent var	0.039700
S.E. of regression	0.016949	Akaike info criterion	-5.127519
Sum squared resid	0.005171	Schwarz criterion	-4.880672
Log likelihood	63.96646	Hannan-Quinn criter.	-5.065437
Durbin-Watson stat	2.575770		

* p-value incompatible with t-Bounds distribution.

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BC_GDP	0.000378	0.001009	0.374700	0.7166
FINL	-0.001453	0.002090	-0.695045	0.5046
TURN	0.001933	0.002581	0.748804	0.4731
VASTR	8.90E-05	0.001022	0.087164	0.9324
LCERS	-0.077439	0.125558	-0.616760	0.5527
LCIF	-0.106238	0.159612	-0.665601	0.5224
LMVA	0.644427	0.274768	2.345353	0.0436
URB	0.021611	0.027124	0.796755	0.4461
C	-0.516525	3.622009	-0.142607	0.8897

EC = LGHG - (0.0004*BC_GDP -0.0015*FINL + 0.0019*TURN + 0.0001
*VASTR -0.0774*LCERS -0.1062*LCIF + 0.6444*LMVA + 0.0216
*URB -0.5165)